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(54) **REMOTELY POWERED REMOTELY ADJUSTABLE GASTRIC BAND SYSTEM**

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(56) **References Cited**

U.S. PATENT DOCUMENTS

1,174,814 A	3/1916	Brennan
1,702,974 A	2/1929	MacDonald

(Continued)

FOREIGN PATENT DOCUMENTS

CA	949965	6/1974
CN	1250382 A	4/2000

(Continued)

OTHER PUBLICATIONS

'Innovative medical devices and implants'; LGSP medical futures, p. 5.

(Continued)

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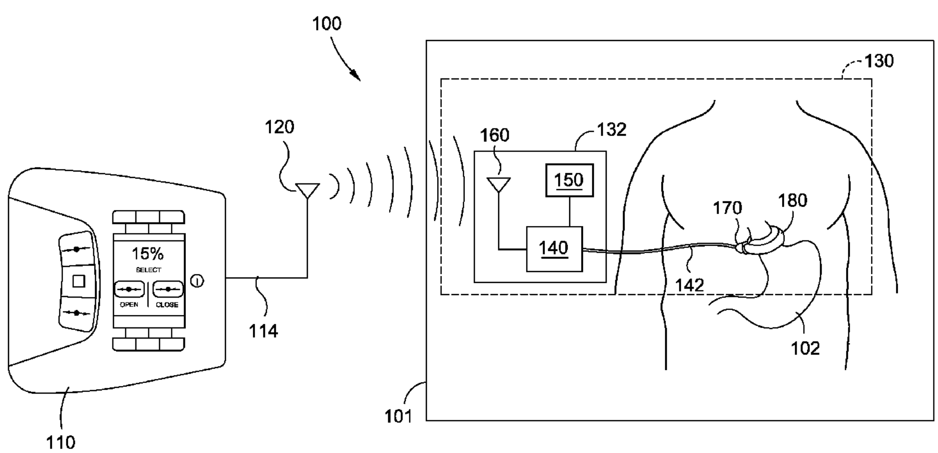
(57) **ABSTRACT**

A remotely adjustable remotely power gastric band system may include a control device, an implant electronic device, and an implantable gastric band. The control device may telemetrically power and communicate with the implant electronic device, which may be used for adjusting the diameter of the implantable gastric band. The implant electronic device may store the gastric band adjustment history records of a patient and regulate the power received from the control device. To improve transmission efficiency, the implant electronic device may adopt a double modulation scheme for communicating with the control device. Furthermore, the implant electronic device may detect and resolve motor blockage issues related to the implantable gastric band.

7 Claims, 70 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

1,830,947	A	11/1931	Klingel
1,999,683	A	4/1935	Borresen
2,163,048	A	6/1939	McKee
2,339,138	A	1/1944	Black
2,405,667	A	8/1946	Andrew
2,438,231	A	3/1948	Schultz
2,635,907	A	4/1953	Heimbuch
2,714,469	A	8/1955	Carlson
2,936,980	A	5/1960	Rapata
3,059,645	A	10/1962	Hasbrouck
3,189,961	A	6/1965	Heller
3,569,660	A	3/1971	Houldcroft
3,587,115	A	6/1971	Shiley
3,596,660	A	8/1971	Melone
3,667,081	A	6/1972	Burger
3,688,764	A	9/1972	Reed
3,719,973	A	3/1973	Bell
3,731,352	A	5/1973	Okamoto
3,840,018	A	10/1974	Heifetz
3,919,724	A	11/1975	Sanders
3,955,834	A	5/1976	Ahlrot
3,958,562	A	5/1976	Hakim
3,971,376	A	7/1976	Wichterle
4,019,499	A	4/1977	Fitzgerald
4,053,176	A	10/1977	Hilbush
4,117,727	A	10/1978	Friswell
4,118,805	A	10/1978	Reimels
4,133,315	A	1/1979	Berman
4,151,835	A	5/1979	Copeland
4,157,713	A	6/1979	Clarey
4,161,943	A	7/1979	Nogier
4,164,943	A	8/1979	Hill
4,176,412	A	12/1979	Peterson
4,190,040	A	2/1980	Schulte
4,233,992	A	11/1980	Bisping
4,236,521	A	12/1980	Lauterjung
4,265,252	A	5/1981	Chubbuck
4,271,827	A	6/1981	Angelchik
4,286,584	A	9/1981	Sampson
4,299,012	A	11/1981	Oetiker
4,370,982	A	2/1983	Reilly
4,399,809	A	8/1983	Baro
4,408,597	A	10/1983	Tenney
4,413,985	A	11/1983	Wellner
4,417,567	A	11/1983	Trick
4,424,208	A	1/1984	Wallace
4,430,392	A	2/1984	Kelley
4,442,153	A	4/1984	Meltsch
4,474,572	A	10/1984	McNaughton
4,485,805	A	12/1984	Foster
4,492,004	A	1/1985	Oetiker
4,502,335	A	3/1985	Wamstad
4,543,088	A	9/1985	Bootman
4,545,367	A	10/1985	Tucci
4,551,862	A	11/1985	Haber
4,557,722	A	12/1985	Harris
4,558,699	A	12/1985	Bashour
4,559,699	A	12/1985	Owen
4,569,675	A	2/1986	Prosl
4,582,640	A	4/1986	Smestad
4,582,865	A	4/1986	Balazs
4,588,394	A	5/1986	Schulte
4,592,339	A	6/1986	Kuzmak
4,592,355	A	6/1986	Antebi
4,598,699	A	7/1986	Garren
4,601,713	A	7/1986	Fuqua
4,603,699	A	8/1986	Himpens
4,607,618	A	8/1986	Angelchik
4,634,427	A	1/1987	Hannula
4,636,213	A	1/1987	Pakiam
4,655,765	A	4/1987	Swift
4,671,351	A	6/1987	Rappe
4,673,394	A	6/1987	Fenton
4,692,146	A	9/1987	Hilger
4,693,695	A	9/1987	Cheng
4,694,827	A	9/1987	Weiner
4,696,288	A	9/1987	Kuzmak
4,704,103	A	11/1987	Stoeber
4,708,140	A	11/1987	Baron
4,710,174	A	12/1987	Moden
4,716,154	A	12/1987	Maelson
4,723,547	A	2/1988	Kullas
4,738,657	A	4/1988	Hancock
4,753,086	A	6/1988	Schmidt
4,760,837	A	8/1988	Petit
4,767,410	A	8/1988	Moden
4,772,270	A	9/1988	Wiita
4,778,452	A	10/1988	Moden
4,781,680	A	11/1988	Redmond
4,796,641	A	1/1989	Mills
4,802,885	A	2/1989	Weeks
4,803,075	A	2/1989	Wallace
4,804,054	A	2/1989	Howson
4,832,054	A	5/1989	Bark
4,840,615	A	6/1989	Hancock
4,850,227	A	7/1989	Luettgen
4,858,619	A	8/1989	Toth
4,858,623	A	8/1989	Bradshaw
4,861,341	A	8/1989	Woodburn
4,872,483	A	10/1989	Shah
4,881,939	A	11/1989	Newman
4,883,467	A	11/1989	Franetzki
4,886,501	A	12/1989	Johnston
4,886,787	A	12/1989	de Belder et al.
4,896,787	A	1/1990	Delamour
4,902,278	A	2/1990	Maget
4,904,241	A	2/1990	Bark
4,913,702	A	4/1990	Yum
4,915,690	A	4/1990	Cone
4,919,650	A	4/1990	Feingold
4,925,446	A	5/1990	Garay
4,929,230	A	5/1990	Pfleger
4,929,236	A	5/1990	Sampson
4,930,535	A	6/1990	Rinehold
4,944,659	A	7/1990	Labbe
4,958,791	A	9/1990	Nakamura
4,966,588	A	10/1990	Rayman
4,967,755	A	11/1990	Pohndorf
4,969,899	A	11/1990	Cox
4,978,338	A	12/1990	Melsky
4,989,756	A	2/1991	Kagamihara
4,994,019	A	2/1991	Fernandez
5,006,115	A	4/1991	McDonald
5,013,298	A	5/1991	Moden
5,026,344	A	6/1991	Dijkstra
5,041,098	A	8/1991	Loiterman
5,045,060	A	9/1991	Melsky
5,074,868	A	12/1991	Kuzmak
5,084,061	A	1/1992	Gau
5,089,019	A	2/1992	Grandjean
5,090,954	A	2/1992	Geary
5,091,171	A	2/1992	Yu
5,092,897	A	3/1992	Forte
5,094,244	A	3/1992	Callahan
5,108,377	A	4/1992	Cone
5,120,313	A	6/1992	Elftman
5,125,408	A	6/1992	Basser
5,133,753	A	7/1992	Bark
5,137,529	A	8/1992	Watson
5,143,724	A	9/1992	Leshchiner
5,147,483	A	9/1992	Melsky
5,152,747	A	10/1992	Olivier
5,152,770	A	10/1992	Bengmark
5,160,338	A	11/1992	Vincent
5,167,638	A	12/1992	Felix
5,171,228	A	12/1992	McDonald
5,185,003	A	2/1993	Brethauer
5,188,609	A	2/1993	Bayless
5,207,644	A	5/1993	Strecker
5,211,371	A	5/1993	Coffee
5,213,574	A	5/1993	Tucker
5,224,494	A	7/1993	Enhorning
5,226,429	A	7/1993	Kuzmak
5,226,894	A	7/1993	Haber

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,246,456 A 9/1993 Wilkinson
5,246,698 A 9/1993 Leshchiner
5,250,026 A 10/1993 Ehrlich
5,259,399 A 11/1993 Brown
5,273,537 A 12/1993 Haskvitz
5,277,333 A 1/1994 Shimano
5,281,205 A 1/1994 McPherson
5,284,479 A 2/1994 de Jong
5,289,817 A 3/1994 Williams
5,300,120 A 4/1994 Knapp
5,318,533 A 6/1994 Adams
5,318,545 A 6/1994 Tucker
5,325,873 A 7/1994 Hirschi
5,326,349 A 7/1994 Baraff
5,336,194 A 8/1994 Polaschegg
5,337,747 A 8/1994 Neftel
5,356,883 A 10/1994 Kuo
5,360,407 A 11/1994 Leonard
5,360,445 A 11/1994 Goldowsky
5,368,040 A 11/1994 Carney
5,383,858 A 1/1995 Reilly
5,387,192 A 2/1995 Glantz
5,391,156 A 2/1995 Hildwein
5,391,164 A 2/1995 Giampapa
5,399,351 A 3/1995 Leshchiner
5,425,716 A 6/1995 Kawasaki
5,449,363 A 9/1995 Brust
5,449,368 A 9/1995 Kuzmak
5,458,568 A 10/1995 Racchini
5,476,460 A 12/1995 Montalvo
5,496,312 A 3/1996 Klicek
5,496,313 A 3/1996 Gentelia
5,509,888 A 4/1996 Miller
5,514,174 A 5/1996 Heil
5,527,340 A 6/1996 Vogel
5,531,716 A 7/1996 Luzio
5,535,752 A 7/1996 Halperin
5,540,648 A 7/1996 Yoon
5,554,113 A 9/1996 Novak
5,556,388 A 9/1996 Johlin
5,558,641 A 9/1996 Glantz
5,562,617 A 10/1996 Finch
5,562,714 A 10/1996 Grevious
5,569,839 A 10/1996 Ajot
5,571,104 A 11/1996 Li
5,575,777 A 11/1996 Cover
5,601,604 A 2/1997 Vincent
5,607,418 A 3/1997 Arzbaecher
5,633,001 A 5/1997 Ågerup
5,637,102 A 6/1997 Tolkoff
5,649,546 A 7/1997 Steinbeck
5,653,718 A 8/1997 Yoon
5,653,755 A 8/1997 Ledergerber
5,658,298 A 8/1997 Vincent
5,674,288 A 10/1997 Knapp
5,674,397 A 10/1997 Pawlak
5,676,162 A 10/1997 Larson
5,681,284 A 10/1997 Herskowitz
5,683,447 A 11/1997 Bush
5,688,237 A 11/1997 Rozga
5,693,014 A 12/1997 Abele
5,695,490 A 12/1997 Flaherty
5,695,504 A 12/1997 Gifford
5,704,893 A 1/1998 Timm
5,713,911 A 2/1998 Racenet
5,716,342 A 2/1998 Dumbraveanu
5,718,682 A 2/1998 Tucker
5,722,957 A 3/1998 Steinbach
5,725,507 A 3/1998 Petrick
5,725,578 A 3/1998 Knapp
5,733,257 A 3/1998 Sternby
5,741,232 A 4/1998 Reilly
5,748,200 A 5/1998 Funahashi
5,758,667 A 6/1998 Slettenmark
5,759,015 A 6/1998 Van Lintel et al.
5,766,232 A 6/1998 Grevious
5,769,877 A 6/1998 Barreras
5,785,295 A 7/1998 Tsai
5,795,333 A 8/1998 Reilly
5,808,203 A 9/1998 Nolan
5,810,735 A 9/1998 Halperin
5,814,019 A 9/1998 Steinbach
5,817,113 A 10/1998 Gifford
5,819,749 A 10/1998 Lee
5,827,529 A 10/1998 Ono
5,833,603 A 11/1998 Kovacs
5,833,654 A 11/1998 Powers
5,833,698 A 11/1998 Hinchliffe
5,843,033 A 12/1998 Ropiak
5,855,609 A 1/1999 Knapp
5,861,014 A 1/1999 Familoni
RE36,176 E 3/1999 Kuzmak
5,883,654 A 3/1999 Katsuyama
5,886,042 A 3/1999 Yu
5,891,089 A 4/1999 Katz
5,902,598 A 5/1999 Chen
5,904,697 A 5/1999 Gifford
5,906,596 A 5/1999 Tallarida
5,910,149 A 6/1999 Kuzmak
5,911,704 A 6/1999 Humes
5,923,001 A 7/1999 Morris
5,928,195 A 7/1999 Malamud
5,931,829 A 8/1999 Burbank
5,932,460 A 8/1999 Mills
5,935,083 A 8/1999 Williams
5,938,669 A 8/1999 Klaiber
5,944,696 A 8/1999 Bayless
5,944,751 A 8/1999 Laub
5,951,512 A 9/1999 Dalton
5,977,431 A 11/1999 Knapp
5,993,473 A 11/1999 Chan
5,997,502 A 12/1999 Reilly
6,010,511 A 1/2000 Murphy
6,013,679 A 1/2000 Kuo
6,024,340 A 2/2000 Lazarus
6,024,704 A 2/2000 Meador
6,030,369 A 2/2000 Engelson
6,039,712 A 3/2000 Fogarty
6,042,345 A 3/2000 Bishop
6,048,309 A 4/2000 Flom
6,067,991 A 5/2000 Forsell
6,074,341 A 6/2000 Anderson
6,074,378 A 6/2000 Mouri
6,083,249 A 7/2000 Familoni
6,090,064 A 7/2000 Reilly
6,090,066 A 7/2000 Schnell
6,090,131 A 7/2000 Daley
6,098,405 A 8/2000 Miyata
6,102,678 A 8/2000 Peclat
6,102,897 A 8/2000 Lang
6,102,922 A 8/2000 Jakobsson
6,117,086 A 9/2000 Shulze
6,123,700 A 9/2000 Mills
6,129,668 A 10/2000 Haynor
6,152,885 A 11/2000 Taepke
6,152,922 A 11/2000 Ouchi
6,164,933 A 12/2000 Tani
6,171,252 B1 1/2001 Roberts
6,171,321 B1 1/2001 Gifford
6,179,569 B1 1/2001 Kojima
6,183,449 B1 2/2001 Sibbitt
6,193,734 B1 2/2001 Bolduc
6,203,523 B1 3/2001 Haller
6,210,345 B1 4/2001 Van Brunt
6,210,347 B1 4/2001 Forsell
6,213,973 B1 4/2001 Eliasen
6,221,024 B1 4/2001 Miesel
6,224,857 B1 5/2001 Romeo
6,234,973 B1 5/2001 Meador
6,258,079 B1 7/2001 Burbank
6,264,676 B1 7/2001 Gellman
6,270,475 B1 8/2001 Bestetti
6,283,949 B1 9/2001 Roorda
6,290,575 B1 9/2001 Shipp

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,305,381 B1 10/2001 Weijand
6,306,088 B1 10/2001 Krausman
6,306,116 B1 10/2001 Hancock
6,321,124 B1 11/2001 Cigaina
6,327,503 B1 12/2001 Familoni
6,349,740 B1 2/2002 Cho
6,371,942 B1 4/2002 Schwartz
6,371,965 B2 4/2002 Gifford
6,387,105 B1 5/2002 Gifford
6,402,717 B1 6/2002 Reilly
6,402,718 B1 6/2002 Reilly
6,417,750 B1 7/2002 Sohn
6,419,696 B1 7/2002 Ortiz
6,432,040 B1 8/2002 Meah
6,439,539 B1 8/2002 Powell
6,443,957 B1 9/2002 Addis
6,443,965 B1 9/2002 Gifford
6,450,173 B1 9/2002 Forsell
6,450,946 B1 9/2002 Forsell
6,451,034 B1 9/2002 Gifford
6,453,907 B1 9/2002 Forsell
6,454,699 B1 9/2002 Forsell
6,454,700 B1 9/2002 Forsell
6,454,701 B1 9/2002 Forsell
6,454,785 B2 9/2002 De Hoyos Garza
6,457,801 B1 10/2002 Fish
6,459,917 B1 10/2002 Gowda
6,460,543 B1 10/2002 Forsell
6,461,293 B1 10/2002 Forsell
6,463,935 B1 10/2002 Forsell
6,464,628 B1 10/2002 Forsell
6,470,213 B1 10/2002 Alley
6,470,892 B1 10/2002 Forsell
6,474,584 B2 11/2002 Ekich
6,475,136 B1 11/2002 Forsell
6,475,192 B1 11/2002 Reilly
6,478,783 B1 11/2002 Moorehead
6,485,496 B1 11/2002 Suyker
6,491,704 B2 12/2002 Gifford
6,491,705 B2 12/2002 Gifford
6,503,264 B1 1/2003 Birk
6,511,490 B2 1/2003 Robert
6,517,556 B1 2/2003 Monassevitch
6,527,701 B1 3/2003 Sayet
6,547,801 B1 4/2003 Dargent
6,562,008 B1 5/2003 Reilly
6,565,582 B2 5/2003 Gifford
6,572,587 B2 6/2003 Lerman
6,579,301 B1 6/2003 Bales
6,589,184 B2 7/2003 Noren
6,601,604 B1 8/2003 Cooper
6,615,084 B1 9/2003 Cigaina
6,622,043 B1 9/2003 Kraus
6,629,776 B2 10/2003 Bell
6,632,239 B2 10/2003 Snyder
6,635,014 B2 10/2003 Starkweather
6,635,020 B2 10/2003 Tripp
6,636,769 B2 10/2003 Govari
6,638,231 B2 10/2003 Govari
6,638,258 B2 10/2003 Schwartz
6,646,628 B2 11/2003 Shirochi
6,647,298 B2 11/2003 Abrahamson
6,647,299 B2 11/2003 Bourget
6,648,823 B2 11/2003 Thompson
6,648,849 B2 11/2003 Tenhuisen
6,658,300 B2 12/2003 Govari
6,664,897 B2 12/2003 Pape
6,665,558 B2 12/2003 Kalgren
6,666,821 B2 12/2003 Keimel
6,666,845 B2 12/2003 Hooper
6,667,725 B1 12/2003 Simons
6,671,550 B2 12/2003 Iaizzo
6,675,049 B2 1/2004 Thompson
6,676,674 B1 1/2004 Dudai
6,681,135 B1 1/2004 Davis
6,685,668 B1 2/2004 Cho
6,689,100 B2 2/2004 Connelly
6,691,047 B1 2/2004 Fredericks
6,704,602 B2 3/2004 Berg
6,715,731 B1 4/2004 Post
6,723,053 B2 4/2004 Ackerman
6,725,726 B1 4/2004 Adolfs
6,729,600 B2 5/2004 Mattes
6,733,478 B2 5/2004 Reilly
6,733,512 B2 5/2004 McGhan
6,733,513 B2 5/2004 Boyle
6,733,519 B2 5/2004 Lashinski
6,746,460 B2 6/2004 Gannoe
6,754,527 B2 6/2004 Stroebel
6,778,927 B2 8/2004 Cha
6,792,309 B1 9/2004 Noren
6,799,698 B2 10/2004 Ono
6,808,513 B2 10/2004 Reilly
6,810,880 B1 11/2004 Jennings
6,811,136 B2 11/2004 Eberhardt
6,813,964 B1 11/2004 Clark
6,820,651 B2 11/2004 Seuret
6,834,201 B2 12/2004 Gillies
6,860,857 B2 3/2005 Noren
6,871,090 B1 3/2005 He
6,889,086 B2 5/2005 Mass
6,915,162 B2 7/2005 Noren
6,916,326 B2 7/2005 Benchetrit
6,921,267 B2 7/2005 van Oostrom et al.
6,929,631 B1 8/2005 Brugger
6,939,299 B1 9/2005 Petersen
6,940,467 B2 9/2005 Fischer
6,953,444 B2 10/2005 Rosenberg
6,964,204 B2 11/2005 Clark
6,966,875 B1 11/2005 Longobardi
6,994,095 B2 2/2006 Burnett
6,997,914 B2 2/2006 Smith
7,017,583 B2 3/2006 Forsell
7,017,883 B2 3/2006 Bayer
7,020,531 B1 3/2006 Colliou
7,021,147 B1 4/2006 Subramanian
7,027,935 B2 4/2006 Shimase
7,037,344 B2 5/2006 Kagan
7,040,349 B2 5/2006 Moler
7,044,933 B2 5/2006 VanDiver
7,048,519 B2 5/2006 Fong
7,054,690 B2 5/2006 Imran
7,056,286 B2 6/2006 Ravenscroft
7,056,305 B2 6/2006 Garza
7,058,434 B2 6/2006 Wang
7,060,080 B2 6/2006 Bachmann
7,063,669 B2 6/2006 Brawner
7,066,486 B2 6/2006 Lee
7,073,387 B2 7/2006 Zdeblick
7,082,843 B2 8/2006 Clark
7,118,526 B2 10/2006 Egle
7,119,062 B1 10/2006 Alvis
7,128,750 B1 10/2006 Stergiopulos
7,131,945 B2 11/2006 Fink
7,144,400 B2 12/2006 Byrum
7,149,587 B2 12/2006 Wardle
7,172,607 B2 2/2007 Hoefle
7,177,693 B2 2/2007 Starkebaum
7,191,007 B2 3/2007 Desai
7,191,011 B2 3/2007 Cantlon
7,195,610 B1 3/2007 Flachbart
7,195,774 B2 3/2007 Carvalho
7,198,250 B2 4/2007 East
7,204,821 B1 4/2007 Clare et al.
7,206,637 B2 4/2007 Salo
7,214,233 B2 5/2007 Gannoe
7,223,239 B2 5/2007 Schulze
7,226,419 B2 6/2007 Lane
7,238,191 B2 7/2007 Bachmann
7,240,607 B2 7/2007 Fish
7,255,675 B2 8/2007 Gertner
7,261,003 B2 8/2007 McDonald
7,263,405 B2 8/2007 Boveja
7,267,645 B2 9/2007 Anderson

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,282,023 B2 10/2007 Frering
7,284,966 B2 10/2007 Xu
7,288,064 B2 10/2007 Boustani
7,297,103 B2 11/2007 Jarsaillon
7,299,082 B2 11/2007 Feldman
7,310,557 B2 12/2007 Maschino
7,311,503 B2 12/2007 Van Lintel et al.
7,311,716 B2 12/2007 Byrum
7,311,717 B2 12/2007 Egle
7,314,443 B2 1/2008 Jordan
7,314,598 B2 1/2008 Nishino
7,314,636 B2 1/2008 Caseres
7,338,433 B2 3/2008 Coe
7,340,306 B2 3/2008 Barrett
7,351,198 B2 4/2008 Byrum
7,351,226 B1 4/2008 Herskowitz
7,351,240 B2 4/2008 Hassler
7,353,747 B2 4/2008 Swayze
7,364,542 B2 4/2008 Jambor
7,366,571 B2 4/2008 Armstrong
7,367,340 B2 5/2008 Nelson
7,367,937 B2 5/2008 Jambor
7,374,557 B2 5/2008 Conlon
7,374,565 B2 5/2008 Hassler
7,390,294 B2 6/2008 Hassler
7,396,353 B2 7/2008 Lorenzen
7,413,547 B1 8/2008 Lichtscheidl
7,416,528 B2 8/2008 Crawford
7,437,951 B2 10/2008 McDonald
7,438,718 B2 10/2008 Milliman
7,445,614 B2 11/2008 Bunodiere
7,457,668 B2 11/2008 Cancel
7,468,038 B2 12/2008 Ye
7,481,763 B2 1/2009 Hassler
7,500,944 B2 3/2009 Byrum
7,502,649 B2 3/2009 Ben-Haim
7,507,221 B2 3/2009 Neer
7,510,530 B2 3/2009 Hashimoto
7,530,943 B2 5/2009 Lechner
7,553,298 B2 6/2009 Hunt
7,561,916 B2 7/2009 Hunt
7,580,746 B2 8/2009 Gilkerson
7,585,280 B2 9/2009 Wilson
7,591,185 B1 9/2009 Mothilal
7,593,777 B2 9/2009 Gerber
7,594,885 B2 9/2009 Byrum
7,599,743 B2 10/2009 Hassler
7,599,744 B2 10/2009 Giordano
7,601,162 B2 10/2009 Hassler
7,615,001 B2 11/2009 Jambor
7,618,365 B2 11/2009 Jambor
7,634,319 B2 12/2009 Schneider
7,651,483 B2 1/2010 Byrum
7,658,196 B2 2/2010 Ferreri
7,670,279 B2 3/2010 Gertner
7,699,770 B2 4/2010 Hassler
7,708,722 B2 5/2010 Glenn
7,712,470 B2 5/2010 Gertner
7,727,141 B2 6/2010 Hassler
7,727,143 B2 6/2010 Birk
7,741,476 B2 6/2010 Lebreton
7,758,493 B2 7/2010 Gingras
7,762,998 B2 7/2010 Birk
7,762,999 B2 7/2010 Byrum
7,763,039 B2 7/2010 Ortiz
7,766,815 B2 8/2010 Ortiz
7,771,439 B2 8/2010 Griffiths
7,775,215 B2 8/2010 Hassler
7,775,966 B2 8/2010 Dlugos
7,775,967 B2 8/2010 Gertner
7,780,590 B2 8/2010 Birk
7,794,386 B2 9/2010 Brooks
7,811,275 B2 10/2010 Birk
7,811,298 B2 10/2010 Birk
7,828,813 B2 11/2010 Mouton
7,832,407 B2 11/2010 Gertner
7,841,978 B2 11/2010 Gertner
7,844,342 B2 11/2010 Dlugos
7,850,660 B2 12/2010 Uth
7,862,502 B2 1/2011 Pool
7,862,546 B2 1/2011 Conlon
7,879,068 B2 2/2011 Dlugos
7,909,754 B2 3/2011 Hassler
7,909,804 B2 3/2011 Stats
7,927,270 B2 4/2011 Dlugos
7,951,067 B2 5/2011 Byrum
8,007,474 B2 8/2011 Uth
2001/0011543 A1 8/2001 Forsell
2002/0013545 A1 1/2002 Soltanpour
2002/0032435 A1 3/2002 Levin
2002/0038105 A1 3/2002 Schwartz
2002/0058969 A1 5/2002 Noren
2002/0072780 A1 6/2002 Foley
2002/0087147 A1 7/2002 Hooper
2002/0091395 A1 7/2002 Gabbay
2002/0095181 A1 7/2002 Beyar
2002/0098097 A1 7/2002 Singh
2002/0123716 A1 9/2002 VanDiver
2002/0133081 A1 9/2002 Ackerman
2002/0139208 A1 10/2002 Yatskov
2002/0152816 A1 10/2002 Kim
2002/0177811 A1 11/2002 Reilly
2002/0183765 A1 12/2002 Adams
2002/0198548 A1 12/2002 Robert
2003/0009123 A1 1/2003 Brugger
2003/0014003 A1 1/2003 Gertner
2003/0019498 A1 1/2003 Forsell
2003/0045775 A1 3/2003 Forsell
2003/0045800 A1 3/2003 Noren
2003/0045902 A1 3/2003 Weadock
2003/0045910 A1 3/2003 Sorensen
2003/0055311 A1 3/2003 Neukermans
2003/0060754 A1 3/2003 Reilly
2003/0060873 A1 3/2003 Gertner
2003/0066536 A1 4/2003 Forsell
2003/0073880 A1 4/2003 Polsky
2003/0078506 A1 4/2003 Noren
2003/0093157 A1 5/2003 Casares
2003/0100910 A1 5/2003 Gifford
2003/0106761 A1 6/2003 Taylor
2003/0120288 A1 6/2003 Benchetrit
2003/0139690 A1 7/2003 Aebli
2003/0148995 A1 8/2003 Piron
2003/0158564 A1 8/2003 Benchetrit
2003/0158569 A1 8/2003 Wazne
2003/0167022 A1 9/2003 Dijkman
2003/0171887 A1 9/2003 Cha
2003/0181890 A1 9/2003 Schulze
2003/0181917 A1 9/2003 Gertner
2003/0191433 A1 10/2003 Prentiss
2003/0208212 A1 11/2003 Cigaina
2003/0213285 A1 11/2003 Wheeler
2004/0000843 A1 1/2004 East
2004/0034479 A1 2/2004 Shimase
2004/0044332 A1 3/2004 Stergiopulos
2004/0049209 A1 3/2004 Benchetrit
2004/0059393 A1 3/2004 Policker
2004/0064110 A1 4/2004 Forsell
2004/0065615 A1 4/2004 Hooper
2004/0068233 A1 4/2004 DiMatteo
2004/0068847 A1 4/2004 Belisle
2004/0069714 A1 4/2004 Ferguson
2004/0082908 A1 4/2004 Whitehurst
2004/0111050 A1 6/2004 Smedley
2004/0133219 A1 7/2004 Forsell
2004/0147816 A1 7/2004 Policker
2004/0148034 A1 7/2004 Kagan
2004/0153106 A1 8/2004 Dudai
2004/0162595 A1 8/2004 Foley
2004/0171942 A1 9/2004 Ackerman
2004/0204692 A1 10/2004 Eliasen
2004/0215159 A1 10/2004 Forsell
2004/0230137 A1 11/2004 Mouton
2004/0235025 A1 11/2004 Mori

(56) **References Cited**

U.S. PATENT DOCUMENTS

2004/0243057	A1	12/2004	Vinten-Johansen
2004/0250819	A1	12/2004	Blair
2004/0254533	A1	12/2004	Schriver
2004/0254536	A1	12/2004	Conlon
2004/0254537	A1	12/2004	Conlon
2004/0260229	A1	12/2004	Meir
2004/0260319	A1	12/2004	Egle
2004/0267288	A1	12/2004	Byrum
2004/0267291	A1	12/2004	Byrum
2004/0267292	A1	12/2004	Byrum
2004/0267293	A1	12/2004	Byrum
2004/0267377	A1	12/2004	Egle
2005/0002984	A1	1/2005	Byrum
2005/0010177	A1	1/2005	Tsai
2005/0038484	A1	2/2005	Knudson
2005/0038498	A1	2/2005	Dubrow
2005/0049578	A1	3/2005	Tu
2005/0055039	A1	3/2005	Burnett
2005/0070875	A1	3/2005	Kulessa
2005/0070934	A1	3/2005	Tanaka
2005/0070937	A1	3/2005	Jambor
2005/0085778	A1	4/2005	Parks
2005/0092093	A1	5/2005	Kang
2005/0100779	A1	5/2005	Gertner
2005/0104457	A1	5/2005	Jordan
2005/0119672	A1	6/2005	Benchetrit
2005/0119674	A1	6/2005	Gingras
2005/0131325	A1	6/2005	Chen
2005/0131352	A1	6/2005	Conlon
2005/0131383	A1	6/2005	Chen
2005/0131485	A1	6/2005	Knudson
2005/0136122	A1	6/2005	Sadozai
2005/0142152	A1	6/2005	Leshchiner
2005/0143765	A1	6/2005	Bachmann
2005/0143766	A1*	6/2005	Bachmann et al. 606/158
2005/0148956	A1	7/2005	Conlon
2005/0149143	A1	7/2005	Libbus
2005/0154274	A1	7/2005	Jarsaillon
2005/0171568	A1	8/2005	Duffy
2005/0177111	A1	8/2005	Ozeri
2005/0183730	A1	8/2005	Byrum
2005/0190070	A1	9/2005	Rudduck
2005/0192531	A1	9/2005	Birk
2005/0192601	A1	9/2005	Demarais
2005/0192615	A1	9/2005	Torre
2005/0192629	A1	9/2005	Saadat
2005/0209573	A1	9/2005	Brugger
2005/0216042	A1	9/2005	Gertner
2005/0226936	A1	10/2005	Agerup
2005/0228415	A1	10/2005	Gertner
2005/0228504	A1	10/2005	Demarais
2005/0240155	A1	10/2005	Conlon
2005/0240156	A1	10/2005	Conlon
2005/0240279	A1	10/2005	Kagan
2005/0244288	A1	11/2005	ONeill
2005/0250979	A1	11/2005	Coe
2005/0251181	A1	11/2005	Bachmann
2005/0251182	A1	11/2005	Bachmann
2005/0261711	A1	11/2005	Okada
2005/0267406	A1	12/2005	Hassler
2005/0267500	A1	12/2005	Hassler
2005/0267533	A1	12/2005	Gertner
2005/0267595	A1	12/2005	Chen
2005/0267596	A1	12/2005	Chen
2005/0271729	A1	12/2005	Wang
2005/0277899	A1	12/2005	Conlon
2005/0283041	A1	12/2005	Egle
2005/0283118	A1	12/2005	Uth
2005/0283119	A1	12/2005	Uth
2005/0288739	A1*	12/2005	Hassler et al. 607/61
2005/0288740	A1	12/2005	Hassler
2006/0009697	A1	1/2006	Banet
2006/0015138	A1	1/2006	Gertner
2006/0020278	A1	1/2006	Burnett
2006/0020298	A1	1/2006	Camilleri
2006/0025799	A1	2/2006	Basu
2006/0041183	A1	2/2006	Massen
2006/0069403	A1	3/2006	Shalon
2006/0074439	A1	4/2006	Garner
2006/0074473	A1	4/2006	Gertner
2006/0079766	A1	4/2006	Neer
2006/0079767	A1	4/2006	Gibbs
2006/0089571	A1	4/2006	Gertner
2006/0122147	A1	6/2006	Wohlrab
2006/0122578	A1	6/2006	Lord
2006/0142700	A1	6/2006	Sobelman
2006/0142790	A1	6/2006	Gertner
2006/0149161	A1	7/2006	Wilson
2006/0161186	A1	7/2006	Hassler
2006/0167531	A1	7/2006	Gertner
2006/0173238	A1	8/2006	Starkebaum
2006/0173423	A1	8/2006	Conlon
2006/0173424	A1	8/2006	Conlon
2006/0178555	A1	8/2006	Bortolotti
2006/0178647	A1	8/2006	Stats
2006/0178648	A1	8/2006	Barron
2006/0183967	A1	8/2006	Lechner
2006/0184141	A1	8/2006	Smith
2006/0189887	A1	8/2006	Hassler
2006/0189888	A1	8/2006	Hassler
2006/0189889	A1	8/2006	Gertner
2006/0190039	A1	8/2006	Birk
2006/0194758	A1	8/2006	Lebreton
2006/0195139	A1	8/2006	Gertner
2006/0197412	A1	9/2006	Rasmussen
2006/0199997	A1	9/2006	Hassler
2006/0211912	A1	9/2006	Dlugos
2006/0211913	A1	9/2006	Dlugos
2006/0211914	A1	9/2006	Hassler
2006/0212051	A1	9/2006	Snyder
2006/0212053	A1	9/2006	Gertner
2006/0217668	A1	9/2006	Schulze
2006/0217673	A1	9/2006	Schulze
2006/0229702	A1	10/2006	Agnew
2006/0235445	A1	10/2006	Birk
2006/0235448	A1	10/2006	Roslin
2006/0246137	A1	11/2006	Hermitte
2006/0247539	A1	11/2006	Schugt
2006/0247721	A1	11/2006	Maschino
2006/0247722	A1	11/2006	Maschino
2006/0252982	A1	11/2006	Hassler
2006/0252983	A1	11/2006	Lembo
2006/0257488	A1	11/2006	Hubbard
2006/0264699	A1	11/2006	Gertner
2006/0264762	A1	11/2006	Starr
2006/0266128	A1	11/2006	Clark
2006/0276812	A1	12/2006	Hill
2006/0293625	A1	12/2006	Hunt
2006/0293626	A1	12/2006	Byrum
2006/0293627	A1	12/2006	Byrum
2006/0293628	A1	12/2006	Hunt
2007/0001447	A1	1/2007	Fennington
2007/0010790	A1	1/2007	Byrum
2007/0015954	A1	1/2007	Dlugos
2007/0015955	A1	1/2007	Tsonton
2007/0015956	A1	1/2007	Crawford
2007/0016231	A1	1/2007	Jambor
2007/0016262	A1	1/2007	Gross
2007/0027356	A1	2/2007	Ortiz
2007/0027358	A1	2/2007	Gertner
2007/0038255	A1	2/2007	Kieval
2007/0044655	A1	3/2007	Fish
2007/0060959	A1	3/2007	Salo
2007/0073250	A1	3/2007	Schneiter
2007/0077292	A1	4/2007	Pinsky
2007/0078391	A1	4/2007	Wortley
2007/0078476	A1	4/2007	Hull
2007/0083224	A1	4/2007	Hively
2007/0088336	A1	4/2007	Dalton
2007/0088391	A1	4/2007	McAlexander
2007/0106153	A1	5/2007	Neer
2007/0125826	A1	6/2007	Shelton
2007/0129765	A1	6/2007	Gilkerson
2007/0135758	A1	6/2007	Childers

(56) **References Cited**

U.S. PATENT DOCUMENTS

2007/0135829	A1	6/2007	Paganon
2007/0147170	A1	6/2007	Hood
2007/0149947	A1	6/2007	Byrum
2007/0156013	A1	7/2007	Birk
2007/0156248	A1	7/2007	Marco
2007/0158769	A1	7/2007	You
2007/0161958	A1	7/2007	Glenn
2007/0167672	A1	7/2007	Dlugos
2007/0167982	A1	7/2007	Gertner
2007/0173685	A1	7/2007	Jambor
2007/0173881	A1	7/2007	Birk
2007/0173888	A1	7/2007	Gertner
2007/0179335	A1	8/2007	Gertner
2007/0185373	A1	8/2007	Tsonton
2007/0185462	A1	8/2007	Byrum
2007/0191717	A1	8/2007	Rosen
2007/0205384	A1	9/2007	Kurosawa
2007/0208313	A1	9/2007	Conlon
2007/0213836	A1	9/2007	Paganon
2007/0213837	A1	9/2007	Ferreri
2007/0218083	A1	9/2007	Brooks
2007/0219510	A1	9/2007	Zinn
2007/0232848	A1	10/2007	Forsell
2007/0232849	A1	10/2007	Gertner
2007/0233170	A1	10/2007	Gertner
2007/0235083	A1	10/2007	Dlugos
2007/0243227	A1	10/2007	Gertner
2007/0250085	A1	10/2007	Bachmann
2007/0250086	A1	10/2007	Wiley
2007/0255165	A1	11/2007	Uesugi
2007/0255234	A1	11/2007	Haase
2007/0255335	A1	11/2007	Herbert
2007/0255336	A1	11/2007	Herbert
2007/0265598	A1	11/2007	Karasik
2007/0265645	A1	11/2007	Birk
2007/0265646	A1	11/2007	McCoy
2007/0265666	A1	11/2007	Roberts
2007/0282196	A1	12/2007	Birk
2007/0288033	A1	12/2007	Murature
2007/0293829	A1	12/2007	Conlon
2007/0298005	A1	12/2007	Thibault
2008/0004642	A1	1/2008	Birk
2008/0009680	A1	1/2008	Hassler
2008/0015406	A1	1/2008	Dlugos
2008/0015501	A1	1/2008	Gertner
2008/0027269	A1	1/2008	Gertner
2008/0027469	A1	1/2008	Bachmann
2008/0039772	A1	2/2008	Chantriaux
2008/0051722	A1	2/2008	Ellsmere
2008/0058632	A1	3/2008	Tai
2008/0071306	A1	3/2008	Gertner
2008/0097496	A1	4/2008	Chang
2008/0108862	A1	5/2008	Jordan
2008/0108896	A1	5/2008	Gibbs
2008/0108941	A1	5/2008	Neer
2008/0108943	A1	5/2008	Wagner
2008/0114302	A1	5/2008	Neer
2008/0114308	A1	5/2008	di Palma et al.
2008/0119798	A1	5/2008	Chantriaux
2008/0147002	A1	6/2008	Gertner
2008/0161717	A1	7/2008	Gertner
2008/0161875	A1	7/2008	Stone
2008/0166028	A1	7/2008	Turek
2008/0167647	A1	7/2008	Gertner
2008/0167648	A1	7/2008	Gertner
2008/0172072	A1	7/2008	Pool
2008/0172079	A1	7/2008	Birk
2008/0188766	A1	8/2008	Gertner
2008/0195092	A1	8/2008	Kim
2008/0208240	A1	8/2008	Paz
2008/0221598	A1	9/2008	Dlugos
2008/0243071	A1	10/2008	Quijano
2008/0243093	A1	10/2008	Kalpin
2008/0249806	A1	10/2008	Dlugos
2008/0250340	A1	10/2008	Dlugos
2008/0250341	A1	10/2008	Dlugos
2008/0255403	A1	10/2008	Voegele
2008/0255414	A1	10/2008	Voegele
2008/0255425	A1	10/2008	Voegele
2008/0255459	A1	10/2008	Voegele
2008/0255537	A1	10/2008	Voegele
2008/0255601	A1	10/2008	Birk
2008/0275294	A1	11/2008	Gertner
2008/0275295	A1	11/2008	Gertner
2008/0275484	A1	11/2008	Gertner
2008/0281347	A1	11/2008	Gertner
2008/0281412	A1	11/2008	Smith
2008/0287969	A1	11/2008	Tsonton
2008/0287974	A1	11/2008	Widenhouse
2008/0287976	A1	11/2008	Weaner
2008/0294097	A1	11/2008	Kim
2008/0300618	A1	12/2008	Gertner
2008/0306443	A1	12/2008	Neer
2008/0312553	A1	12/2008	Timmons
2008/0319435	A1	12/2008	Rioux
2009/0018608	A1	1/2009	Schwartz
2009/0048524	A1	2/2009	Wildau
2009/0054914	A1	2/2009	Lechner
2009/0062825	A1	3/2009	Pool
2009/0062826	A1	3/2009	Steffen
2009/0071258	A1	3/2009	Kouda
2009/0076466	A1	3/2009	Quebbemann
2009/0082757	A1	3/2009	Rogers
2009/0082793	A1	3/2009	Birk
2009/0093768	A1	4/2009	Conlon
2009/0099538	A1	4/2009	Paganon
2009/0105735	A1	4/2009	Stam
2009/0112308	A1	4/2009	Kassem
2009/0118572	A1	5/2009	Lechner
2009/0131968	A1	5/2009	Birk
2009/0149874	A1	6/2009	Ortiz
2009/0157106	A1	6/2009	Marcotte
2009/0157107	A1	6/2009	Kierath
2009/0157113	A1	6/2009	Marcotte
2009/0163803	A1	6/2009	Neer
2009/0171375	A1	7/2009	Coe
2009/0171378	A1	7/2009	Coe
2009/0171379	A1	7/2009	Coe
2009/0187202	A1	7/2009	Ortiz
2009/0188494	A1	7/2009	Imai
2009/0192404	A1	7/2009	Ortiz
2009/0192415	A1	7/2009	Ortiz
2009/0192533	A1	7/2009	Dlugos
2009/0192534	A1	7/2009	Ortiz
2009/0192541	A1	7/2009	Ortiz
2009/0198261	A1	8/2009	Schweikert
2009/0202387	A1	8/2009	Dlugos
2009/0204131	A1	8/2009	Ortiz
2009/0204132	A1	8/2009	Ortiz
2009/0204141	A1	8/2009	Dlugos
2009/0204179	A1	8/2009	Dlugos
2009/0209995	A1	8/2009	Byrum
2009/0216193	A1	8/2009	Schriver
2009/0216255	A1	8/2009	Coe
2009/0220176	A1	9/2009	Fusco
2009/0221974	A1	9/2009	Paganon
2009/0222028	A1	9/2009	Dlugos
2009/0222031	A1	9/2009	Axelsson
2009/0222065	A1	9/2009	Dlugos
2009/0227862	A1	9/2009	Smith
2009/0228028	A1	9/2009	Coe
2009/0228063	A1	9/2009	Dlugos
2009/0228072	A1	9/2009	Coe
2009/0241677	A1	10/2009	Klees
2009/0248125	A1	10/2009	Brostrom
2009/0248126	A1	10/2009	Nippoldt
2009/0254052	A1	10/2009	Birk
2009/0259190	A1	10/2009	Birk
2009/0259191	A1	10/2009	Birk
2009/0259246	A1	10/2009	Eskaros
2009/0264901	A1	10/2009	Franklin
2009/0270759	A1	10/2009	Wilson
2009/0270904	A1	10/2009	Birk
2009/0299216	A1	12/2009	Chen

(56) **References Cited**

U.S. PATENT DOCUMENTS

2009/0299672	A1	12/2009	Zhang
2009/0306462	A1	12/2009	Lechner
2009/0308169	A1	12/2009	Mothilal
2009/0312635	A1	12/2009	Shimchuk
2009/0312785	A1	12/2009	Stone
2010/0010291	A1	1/2010	Birk
2010/0087843	A1	4/2010	Bertolote
2010/0099945	A1	4/2010	Birk
2010/0100079	A1	4/2010	Berkcan
2010/0114149	A1	5/2010	Albrecht
2010/0130941	A1	5/2010	Conlon
2010/0145378	A1	6/2010	Gertner
2010/0152532	A1	6/2010	Marcotte
2010/0168508	A1	7/2010	Gertner
2010/0168783	A1	7/2010	Murature
2010/0174307	A1	7/2010	Birk
2010/0185049	A1	7/2010	Birk
2010/0191265	A1	7/2010	Lau
2010/0191271	A1	7/2010	Lau
2010/0204647	A1	8/2010	Gertner
2010/0204723	A1	8/2010	Gertner
2010/0211085	A1	8/2010	Uth
2010/0217198	A1	8/2010	Franklin
2010/0217199	A1	8/2010	Uth
2010/0217200	A1	8/2010	Uth
2010/0226988	A1	9/2010	Lebreton
2010/0228080	A1	9/2010	Tavori
2010/0234682	A1	9/2010	Gertner
2010/0234808	A1	9/2010	Uth
2010/0249803	A1	9/2010	Griffiths
2010/0274194	A1	10/2010	Sobelman
2010/0280310	A1	11/2010	Raven
2010/0305397	A1	12/2010	Birk
2010/0312147	A1	12/2010	Gertner
2010/0324358	A1	12/2010	Birk
2010/0324359	A1	12/2010	Birk
2011/0082426	A1	4/2011	Conlon
2011/0130626	A1	6/2011	Hassler
2011/0201874	A1	8/2011	Birk

FOREIGN PATENT DOCUMENTS

CN	1367670	A	9/2002
DE	8804765	U1	5/1989
DE	3927001		2/1991
DE	4211045		10/1993
DE	4225524		2/1994
DE	19745654		4/1999
DE	19751791		5/1999
DE	19802615	A1	8/1999
DE	10020688		12/2000
DE	102007025312	A1	11/2008
EP	0119596		9/1984
EP	0230747		8/1987
EP	0343910	A2	11/1989
EP	0416250		3/1991
EP	0611561		8/1994
EP	0695558		2/1996
EP	0858814		8/1998
EP	0867197		9/1998
EP	0867808		11/1998
EP	1036545	A2	9/2000
EP	1057457		12/2000
EP	1072282		1/2001
EP	1105073		6/2001
EP	1346753		9/2003
EP	1396242	A1	3/2004
EP	1396243	A1	3/2004
EP	1488824	A1	12/2004
EP	1491167		12/2004
EP	1491168		12/2004
EP	1529502		5/2005
EP	1543861	A1	6/2005
EP	1547549	A2	6/2005
EP	1547643		6/2005
EP	1574189		9/2005
EP	1591140	A1	11/2005
EP	1600183	A1	11/2005
EP	1602346	A1	12/2005
EP	1704833	A2	9/2006
EP	1719480	A2	11/2006
EP	1754890		11/2006
EP	1736123	A1	12/2006
EP	1736194	A1	12/2006
EP	1736195		12/2006
EP	1736196		12/2006
EP	1736197		12/2006
EP	1736198		12/2006
EP	1736199		12/2006
EP	1736202		12/2006
EP	1743605	A1	1/2007
EP	1774929	A2	4/2007
EP	1829504		9/2007
EP	1829505		9/2007
EP	1829506		9/2007
EP	1870126		12/2007
EP	1949875		7/2008
EP	1967168	A2	9/2008
EP	1985263		10/2008
EP	1992315		11/2008
EP	1992316	A2	11/2008
EP	2070494	A1	6/2009
EP	2074970	A1	7/2009
EP	2074971	A1	7/2009
EP	2087862	A1	8/2009
EP	2095796	A1	9/2009
EP	2095797	A2	9/2009
EP	2095798		9/2009
FR	1566202		5/1969
FR	2688693		9/1993
FR	2740977		5/1997
FR	2769491		4/1999
FR	2783153		3/2000
FR	2797181	A1	2/2001
FR	2799118		4/2001
FR	2823663	A1	10/2002
FR	2851168		8/2004
FR	2852821	A1	10/2004
FR	2855744	A1	12/2004
FR	2916980		12/2008
FR	2921822	A1	4/2009
FR	2941617	A1	8/2010
GB	1174814	A	12/1969
GB	2086792	A	5/1982
GB	2090747		7/1982
JP	57171676		10/1982
JP	S63279854	A	11/1988
JP	1049572	A	2/1989
JP	167309		4/1989
JP	2019147		1/1990
JP	2119877		5/1990
JP	2132104		11/1990
JP	3105702		11/1991
JP	8107934		4/1996
JP	63264078		10/1998
JP	11244395		9/1999
JP	2003526410		9/2003
JP	2005131380		5/2005
JP	2005334658		12/2005
SE	8503144		12/1986
SU	1823791		6/1991
WO	8600079		1/1986
WO	8600912		2/1986
WO	8911701		11/1989
WO	9000369		1/1990
WO	9220349		11/1992
WO	9402517		2/1994
WO	9422520		10/1994
WO	9633751		1/1996
WO	9640357		12/1996
WO	9701370		1/1997
WO	9835639		8/1998
WO	9835640		8/1998

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

WO	9920338		4/1999
WO	9926543		6/1999
WO	9934859		7/1999
WO	0000108	A1	1/2000
WO	0001428		1/2000
WO	0009047	A1	2/2000
WO	0009048	A1	2/2000
WO	0015158	A1	3/2000
WO	0033901		6/2000
WO	0066196		11/2000
WO	0110359	A1	2/2001
WO	0112078	A1	2/2001
WO	0141671		6/2001
WO	0147435		7/2001
WO	0147575	A2	7/2001
WO	0149245	A2	7/2001
WO	0152777		7/2001
WO	0166166	A2	9/2001
WO	0168007		9/2001
WO	0170131		9/2001
WO	0180926		11/2001
WO	0185071		11/2001
WO	0195813	A1	12/2001
WO	0205753		1/2002
WO	0209792		2/2002
WO	0219953		3/2002
WO	0226317		4/2002
WO	0235980	A2	5/2002
WO	02053093		7/2002
WO	02065948		8/2002
WO	02074381		9/2002
WO	02096326		12/2002
WO	03007782		1/2003
WO	03055419		7/2003
WO	03055420		7/2003
WO	03057092		7/2003
WO	03059215		7/2003
WO	03077191		9/2003
WO	03101352	A1	12/2003
WO	03105732	A1	12/2003
WO	2004014245		2/2004
WO	2004016971		2/2004
WO	2004019671		3/2004
WO	2004030536		4/2004
WO	2004108025		12/2004
WO	2004112563	A2	12/2004
WO	2005007231		1/2005
WO	2005007232		1/2005
WO	2005009305		2/2005
WO	2005037055		4/2005
WO	2005067994		7/2005
WO	2005072195		8/2005
WO	2005072627		8/2005
WO	2005087147		9/2005
WO	2005094447		10/2005
WO	2005112888		12/2005
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WO	2006049725		5/2006
WO	2006020370		6/2006
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WO	2006090018		8/2006
WO	2006096686		9/2006
WO	2006108203	A2	10/2006
WO	2006118744	A1	11/2006
WO	2007067206		6/2007
WO	2007081304	A2	7/2007
WO	2007106727	A2	9/2007
WO	2007011086		10/2007
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WO	2008063673		5/2008
WO	2008109300	A2	9/2008
WO	2008134755		11/2008
WO	2009007526		1/2009
WO	2009023247		2/2009
WO	2009050709		4/2009
WO	2009129474	A1	10/2009
WO	2009132127	A1	10/2009
WO	2009136126	A2	11/2009
WO	2010042062	A1	4/2010
WO	2010042493		4/2010

OTHER PUBLICATIONS

Acuna-Goycolea et al.; 'Mechanism of Neuropeptide Y, Peptide YY, and Pancreatic Polypeptide Inhibition of Identified Green Fluorescent Protein-Expressing GABA Neurons in the Hypothalamic Neuroendocrine Acruate Nucleus'; The Journal of Neuroscience; V. 25(32); pp. 7406-7419; Aug. 10, 2005.

Adrian et al.; 'Mechanism of Pancreatic Polypeptide Release in Man.' The Lancet; pp. 161-163; Jan. 22, 1977.

Anson; 'Shape Memory Alloys—Medical Applications,' Source: Materials World, vol. 7, No. 12, pp. 745-747, Dec. 1999.

Asakawa et al; 'Antagonism of Ghrelin Receptor Reduces Food Intake and Body Weight Gain in Mice'; Gut.; V.52; pp. 947-952; 2003.

Baggio et al. 'Biology of Integrins: GLP-1 and GIP'; Gastroenrology; V. 132; pp. 2131-2157; 2007.

Ballantyne; 'Peptide YY(1-36) and Peptide YY(3-36): Part I. Distribution, Release, and Actions'; Obesity Surgery; V.16; pp. 651-658; 2006.

Ballantyne; "Peptide YY(1-36) and Peptide YY(3-36): Part II. Changes after Gastrointestinal Surgery and Bariatric Surgery"; Obesity Surgery; V.16; pp. 795-803; 2006.

Berne et al; 'Physiology'; V. 5; pp. 55-57, 210, 428, 540, 554, 579, 584, 591; 2004.

BioEnterics Corporation, an Inamed Company, BioEnterics Intragastric Balloon; Directions for Use Published Document, P/N. 94200 Rev: B, pp. 1-56.

Bio Enterics Lap-Band Adjustable Gastric Banding System, Inamed Health, pub. Aug. 28, 2003, pp. 1-115.

Boulant et al.; 'Cholecystokinin in Transient Lower Oesophageal Sphincter Relation Due to Gastric Distension in Humans'; Gut; V. 40; pp. 575-581; 1997.

Bradjewin et al; 'Dose Ranging Study of the Effects of Cholecystokinin in Healthy Volunteers'; J. Psychiatr. Neurosci.; V. 16 (2); pp. 91-95; 1991.

Burdyga et al.; 'Cholecystokinin Regulates Expression of Y2 Receptors in Vagal Afferent Neurons Serving the Stomach'; The Journal of Neuroscience; V. 28; No. 45; pp. 11583-11592; Nov. 5, 2008.

Chaptini et al.; "Neuroendocrine Regulation of Food Intake"; Current Opinion in Gastroenterology; V. 24; pp. 223-229; 2008.

Chaudhri; 'Can Gut Hormones Control Appetite and Prevent Obesity?' Diabetes Care; V. 31; Supp 2; pp. S284-S289; Feb. 2008.

Cohen et al.; 'Oxyntomodulin Suppresses Appetite and Reduces Food in Humans'; J. Clin. Endocrinol. Metab.; V. 88; pp. 4696-4701; 2003.

Corno et al.; 'A new implantable device for telemetric control of pulmonary blood flow'; New ideas; received in revised form Jul. 12, 2002; 10 pages.

Corno et al.; 'FlowWatchTM in clipped and inclipped position'; Interact Cardio Vase Thorac Surg 2002; 1:46-49; Copyright © 2002 The European Asociation for Cardio-thoracic Surgery; 1 page.

Cummings et al.; 'Plasma Ghrelin Levels After Diet-Induced Weight Loss or Gastric Bypass Surgery'; N. Engl J. Med; V. 346, No. 21; pp. 1623-1630; May 23, 2002.

Cummings; 'Gastrointestinal Regulation of Foot Intake'; The Food Journal of Clinical Investigation; V. 117, N. 1; pp. 13-23; Jan. 2007.

Dakin et al.; 'Oxyntomodulin Inhibits Food Intake in the Rat'; Endocrinology; V. 142; pp. 4244-4250; 2001.

Dakin et al.; 'Peripheral Oxyntomodulin Reduces Food Intake and Body Weight gain in Rats'; Endocrinology; V. 145; No. 6; pp. 2687-2695; Jun. 2004.

Davison; 'Activation of Vagal-Gastric Mechanoreceptors by Cholecystokinin'; Proc. West. Pharmocol. Soc; V. 29; pp. 363-366; 1986.

(56) **References Cited**

OTHER PUBLICATIONS

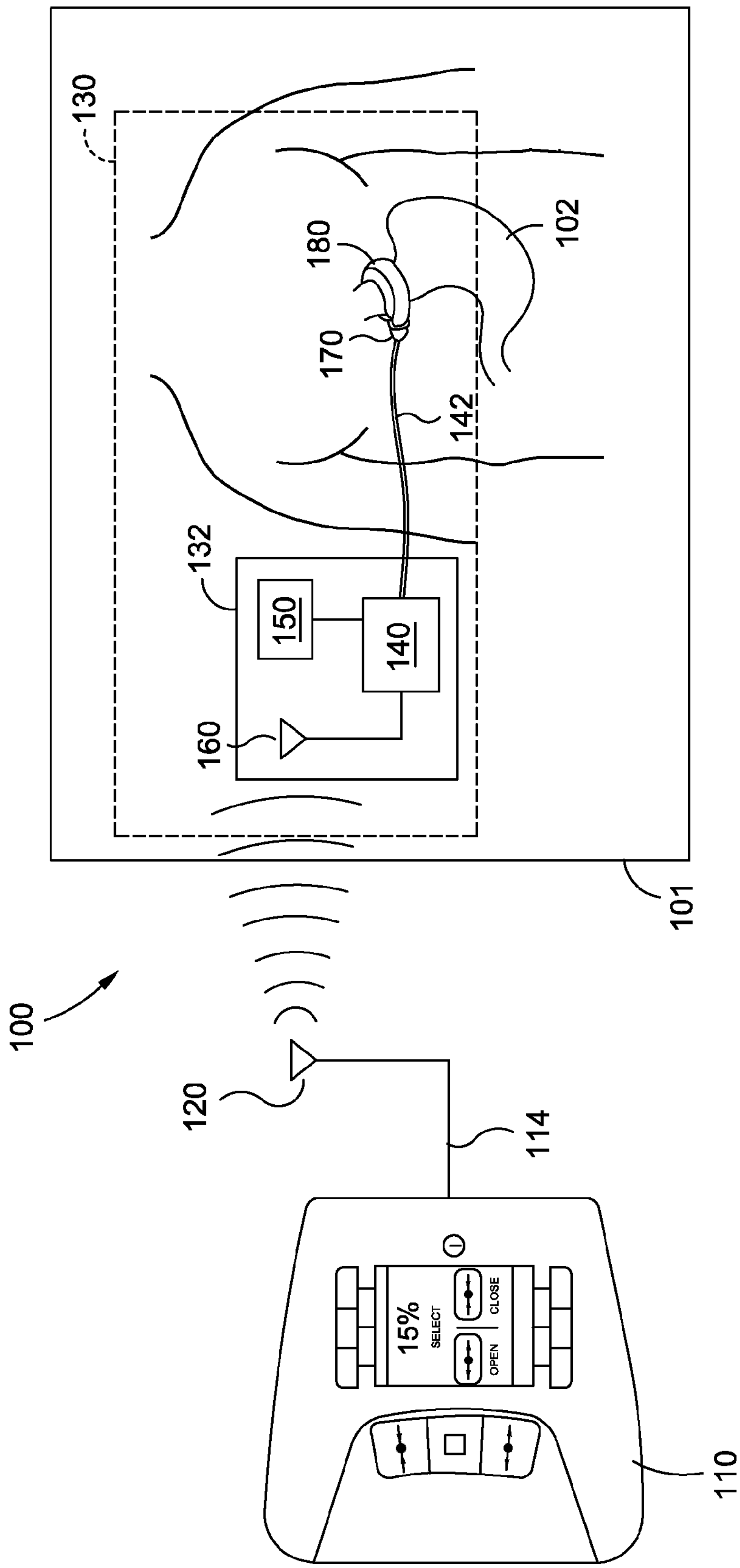
De Waele et al.; "Endoscopic Volume Adjustment of Intragastric Balloons for Intolerance"; Obesity Surgery; V. 11; pp. 223-224; 2001.
De Waele et al.; "Intragastric Balloons for Preoperative Weight Reduction"; Obesity Surgery; V. 58; pp. 58-60; 2001.
Desai et al.; 'Molecular Weight of Heparin Using 13C Nuclear Magnetic Resonance Spectroscopy' Journal of Pharmaceutical Science, V. 84,12; 1995, Abstract only.
Doldi et al.; 'Intragastric Balloon: Another Option for Treatment of Obesity and Morbid Obesity'; Hepato-Gastroenterology; V. 51, N. 55; pp. 294-307; Jan.-Feb. 2004.
Doldi et al.; 'Treatment of Morbid Obesity with Intragastric Balloon in Association with Diet'; Obesity Surgery; V. 10, pp. 583-587; 2000.
Ekblad et al.; 'Distribution of Pancreatic Peptide and Peptide-YY'; Peptides; V. 23; pp. 251-261 ;2002.
El Khoury et al.; "Variation in Postprandial Ghrelin Status Following Ingestion of High-Carbohydrate, High Fat, and High Protein Meals in Males"; Ann Nutr Metab; V. 50; pp. 260-269; 2006.
Galloro et al; "Preliminary Endoscopic Technical Report of an New Silicone Intragastric Balloon in the Treatment of Morbid Obesity"; Obesity Surgery; V. 9, pp. 68-71; 1999.
GinShiCel MH Hydroxy Propyl Methyl Cellulose, Web Page http://www.ginshicel.cn/MHPC.html, Nov. 12, 2008.
Girard; 'The Incretins: From the concept to their use in the treatment of type 2 diabetes. Part A: IncretinsIncretinsIncretinsIncretinsIncretins: Concept and physiological functions'; Diabetes and Metabolism; V. 34; pp. 550-559; 2008.
Greenough et al.; 'Untangling the Effects of Hunger, Anxiety and Nausea on Energy Intake During Intravenous Cholecystokinin Octapeptide (CCK-8) Infusion' Physiology and Behavior; V. 65 (2); pp. 303-310; 1998.
Grise et al.; "Peptide YY Inhibits Growth of Human Breast Cancer in Vitro and in Vivo"; Journal of Surgical Research; V. 82; pp. 151-155; 1999.
Grundy; "Signaling the State of the Digestive Tract"; Autonomic Neuroscience: Basic and Clinical; V. 125; pp. 76-80; 2006.
Grundy; "Vagal Control of Gastrointestinal Function"; Bailliere's Clinical Gastroenterology; V. 2; No. 1; pp. 23-43; 1988.
Hallden et al. "Evidence for a Role of the Gut Hormone PYY in the Regulation of Intestinal Fatty Acid Binding Protein Transcripts in Differentiated Subpopulations of Intestinal Epithelial Cell Hybrids"; Journal of Biological Chemistry; V. 272 (19); pp. 125916-126000; 1997.
Hameed et al., 'Gut Hormones and Appetite Control', Oral Diseases, 2009, 15:18-26.
Hassan et al.; 'Effects of Adjuvants to Local Anesthetics on Their Duration III Experimental Studies of Hyaluronic Acid' Abstract Pub Med [Acta Anesthesiol Scand.; 29 (4): 384-8], 1 page; May 1985.
Hodson et al.; 'Management of Obesity with the New Intragastric Balloon'; Obesity Surgery; V. 11, pp. 327-329,2001.
Holzer; "Gastrointestinal Afferents as Targets of Novel Drugs for the Treatment of Functional Bowel Disorders and Visceral Pain"; European Journal of Pharmacology; V. 429; pp. 177-193; 2001.
Houpt; 'Gastrointestinal Factors in Hunger and Satiety'; Neurosci. and Behav. Rev.; V. 6; pp. 145-164; 1982.
Iverson et al.; 'Recent Advances in Microscale Pumping Technologies: A Review and Evaluation'; Microfluid Nanofluid; vol. 5; pp. 145-174; Feb. 19, 2008.
Jones; "Molecular, pharmacological, and clinical aspects of liraglutide, a oncedaily human GLP-1 analogue"; Molecular and Cellular Endocrinology; V. 297; pp. 137-140; 2009.
Kerem et al.; 'Exogenous Ghrelin Enhances Endocrine and Exocrine Regeneration in Pancreatectomized Rats'; J. Gastrointest Surg.; V. 13; pp. 775-783, 2009.
Kesty et al., 'Hormone-based Therapies in the Regulation of Fuel Metabolism and Body Weight', Expert Opin. Biol. Ther., 2008, 8(11): 1733-1747.
Kissileff et al.; 'Peptides that Regulate Food Intake: Cholecystokinin and Stomach Distension Combine to Reduce Food Intake in Humans'; Am. J. Physiol. Regul. Integr. Comp. Physiol.; V. 285; pp. 992-998; 2003.
Kojima et al., 'A Role for Pancreatic Polypeptide in Feeding and Body Weight Regulation', Peptides, 2007, 28:459-463.
Kulicke et al. "Visco-Elastic Propeerties of Sodium Hyaluronate Solutions," American Institute of Physics; pp. 585-587; 2008.
Lap-Band AP System Adjustable Gastric Banding System With OmniformTM Design: Directions for Use (DFU); Allergan, 16 pages; 2009.
Le Roux et al.; 'Gut Hormone Profiles Following Bariatric Surgery Favor an Anorectic State, Facilitate Weight Loss, and Improve Metabolic Parameters'; Ann. Surg; V. 243; No. 1; pp. 108-114; Jan. 2006.
Liu et al.; 'Adjuvant Hormonal Treatment With Peptide YY or Its Analog Decreases Human Pancreatic Carcinoma Growth'; The American Journal of Surgery; V. 171; pp. 192-196; Jan. 1996.
Mathus-Vliegen et al. 'Intragastric Balloons for Morbid Obesity: Results, Patient Tolerance and Balloon Life Span'; Br. J. Surg.; V. 77, No. 7, pp. 76-79; Jan. 1990.
Mathus-Vliegen et al. "Treating Morbid and Supermorbid Obesity" International Journal of Gastroenterology; V. 5, No. 1, pp. 9-12; 2000.
Medeiros et al.; 'Processing and metabolism of Peptide-YY: Pivotal roles of Dipeptidase-IV, Aminopeptidase-P, and Endopeptidase-24. 11'; Endocrinology; V. 134, No. 5; pp. 2088-2094;1994.
Naslund et al.; 'Prandial Subcutaneous Injection of Glucagon-Like Peptide'; Br. J. Nutr.; V. 91; pp. 439-446; 2004.
Potier et al.; "Protein, amino acids, and the control of food intake"; Current Opinion in Clinical Nutrition and Metabolic Care; V. 12; pp. 54-58; 2009.
Qjan et al.; 'Pulmonary delivery of a GLP-1 receptor agonist, BMS-686117'; International Journal of Pharmaceutics; V. 366; pp. 218-220; 2008.
Rang et al.; 'Pharmacology'; V. 5; pp. 203, 397,402, 524; 2004.
Raybould et al.; "Integration of Postprandial Gastrointestinal Tract: Role of CCK and Sensory Pathways"; Annals of New York Academy of Science; pp. 143-156; 1994.
Renshaw et al. 'Peptide YY: A Potential Therapy for Obesity'; Current Drug Targets; V. 6; pp. 171-179; 2005.
Sannino et al., 'Crosslinking of Cellulose Derivatives and Hyaluronic Acid with Water-Soluble Carbodiimide,' Polymer 46(2005)pp. 11206-11212.
Shechter et al.; "Reversible PEGylation of peptide YY3-36 prolongs its inhibition of food intake in mice"; FEBS Letters; V. 579; pp. 2439-2444; 2005.
Silver et al.; 'Physical Properties of Hyaluronic Acid and Hydroxypropylmethylcellulose in Solution: Evaluation of Coating Ability' Journal of Applied Biomaterials, V. 5; pp. 89-98, 1994.
Small et al.; 'Gut hormones and the control of appetite'; Trends in Endocrinology and Metabolism; V. 15; No. 6; pp. 259-263; Aug. 2004.
Stanley et al.; 'Gastrointestinal Satiety Signals III. Glucagon-like Peptide 1, oxyntomodulin, peptide YY, and pancreatic polypeptide'; Am. J. Physiol Gastrointest Liver Physiol; V. 286; pp. 693-697; 2004.
Tezel, 'The Science of Hyaluronic Acid Dermal Fillers,' Journal of Cosmetic and Laser Therapy (2008) 10: pp. 35-42.
Tolhurst et al.; 'Nutritional regulation of glucagon-like peptidel secretion'; J. Physiol.; V. 587, No. I;pp. 27-32; 2009.
Totte et al.; "Weight Reduction by Means of Intragastric Device: Experience with the Bioenterics Intragastric Balloon"; Obesity Surgery; V. 11, pp. 519-523; 2001.
Tough et al.; 'Y4 Receptors Mediate the Inhibitory Responses of Pancreatic Polypeptide in Human and Mouse Colon Mucosa'; The Journal of Pharmacology and Experimental Therapeutics; V. 319, No. 1; pp. 20-30; 2006.
Tseng et al; "Peptide YY and cancer: Current findings and potential clinical applications"; Peptides; V. 23; pp. 389-395; 2002.
Valassi et al.; "Neuroendocrine control of food intake"; Nut. Metab. & Cariovasc. Disease; V. 18; pp. 158-168; 2008.
Van Der Lely et al.; "Biological, Physiological, Pathophysiological Aspects of Ghrelin"; Endocrine Reviews; V. 25, No. 3; pp. 426-457; 2004.

(56) **References Cited**

OTHER PUBLICATIONS

Verdich et al. 'A Meta-Analysis of the Effect of Glucagon-Like-Peptide-1 (7-36) Amide on ad Libitum Energy Intake in Humans'; J. Clin. Endocrinal. Metab. V. 86; pp. 4382-4389; Sep. 2001.
Wahlen et al.; 'The BioEnterics Intragastric Balloon (BIB): How to Use It'; Obesity Surgery; V. 11; pp. 524-527; 2001.
Wang et al.; "Plasma Ghrelin Modulation in Gastric Band Operation and Sleeve Gastrectomy"; Obes. Surg.; pp. 357-362; 2008.
Weiner et al.; 'Preparation of Extremely Obese Patients for Laparoscopic Gastric Banding by Gastric Balloon Therapy'; Obesity Surgery; V. 9, pp. 261-264, 1999.
Wynne et al.; 'Subcutaneous Oxyntomodulin Reduces Body Weight in Overweight and Obese Subiects: A Double-Blind Randomized, Controlled Trial': Diabetes; V. 54; pp. 2390-2395; 2005.
Yamagami, Takuji; 'Technical Developments; Use of Targeting Guide Wire in Left Subclavian Puncture During Percutaneous Implantation of Port-Catheter Systems Using the Catheter Tip Fixation Method' European Radiology; vol. 13; pp. 863-866; 2003.
Yurdumakan B., et al.; 'Synthetic Gecko Foot-Hairs from Multiwalled Carbon Nanotubes'; The Royal Society of Chemistry; p. 3799-3801; 2005.
Yuzuriha et al.; "Gastrointestinal Hormones (anorexigenic peptide YY and orexigenic ghrelin) influence neural tube development"; FASEB J.; V. 21; pp. 2108-2112; 2007.
'Living With the Bib/BioEnterics Intragastric Balloon Program,' Inamed Health; 1-10 Patient Information Brochure; pp.; May 1, 2005.
BIB Bioenterics Intragastric Balloon Program, 'Take Control of Your Weight and Your Life/The Solution for You,' Inamed Health, pp. 1-2; Jan. 19, 2004.
BIB Bioenterics Intragastric Balloon Program, 'Taking the Next Step/Take Control of Your Weight and Your Life,' Inamed Health, pp. 1-9; Apr. 29, 2004.
BIB Data Sheet Directions for Use, 'BioEnterics Intragastric Balloon System,' Inamed Health, 1-12 pp.
Brown et al; 'Symmetrical Pouch Dilation After Laparoscopic Adjustable Gastric Banding: Incidence and Management'; Obesity Surgery; V. 18, pp. 1104-1108; 2008.
Ceelen et al.; 'Surgical Treatment of Severe Obesity With a Low-Pressure Adjustable Gastric Band: Experimental Data and Clinical Results in 625 Patients'; Annals of Surgery; V. 237, No. I;pp. 10-16; 2003.
Dixon et al.; 'Pregnancy After Lap-Band Surgery: Management of the Band to Achieve Healthy Weight Outcomes'; Obesity Surgery; V. 11, pp. 59-65; 2001.
Helioscopie Product Insert for Heliogast, pp. 1-11 (undated).
Neary et al.; 'Peptide YY(3-36) and Glucagon-Like Peptide-1.sub.(7-36) Inhibit Food Intake Additively'; Endocrinology; V.146; pp. 5120-5127; 2005.
Padidela et al.; 'Elevated basal and post-feed glucagon-like petide 1 (GLP-1) concentrations in the neonatel period'; European Journal of Endocrinology; v. 160; pp. 53-58; 2009.
Patient Management After Lap-Band Placement; http://www.core.monash.org/patient-care.pdf.
Shi et al; 'Sexually Dimorphic Responses to Fat Loss After Caloric Restriction or Surgical Lipectomy'; Am. J. Physiol. Endocrinol. Metab.; V. 293; E316-E326; 2007.
The Lap-Band Device & How it Works; http://lapband.com/en/learn_about-lapband/device_how_it_works/.
Xanthakos et al.; 'Bariatric Surgery for Extreme Adolescent Obesity: Indications, Outcomes, and Physiologic Effects on the Gut-Brain Axis'; Pathophysiology; V. 15; pp. 135-146; 2008.

* cited by examiner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101
102
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SELECT
OPEN
CLOSE

FIG. 1

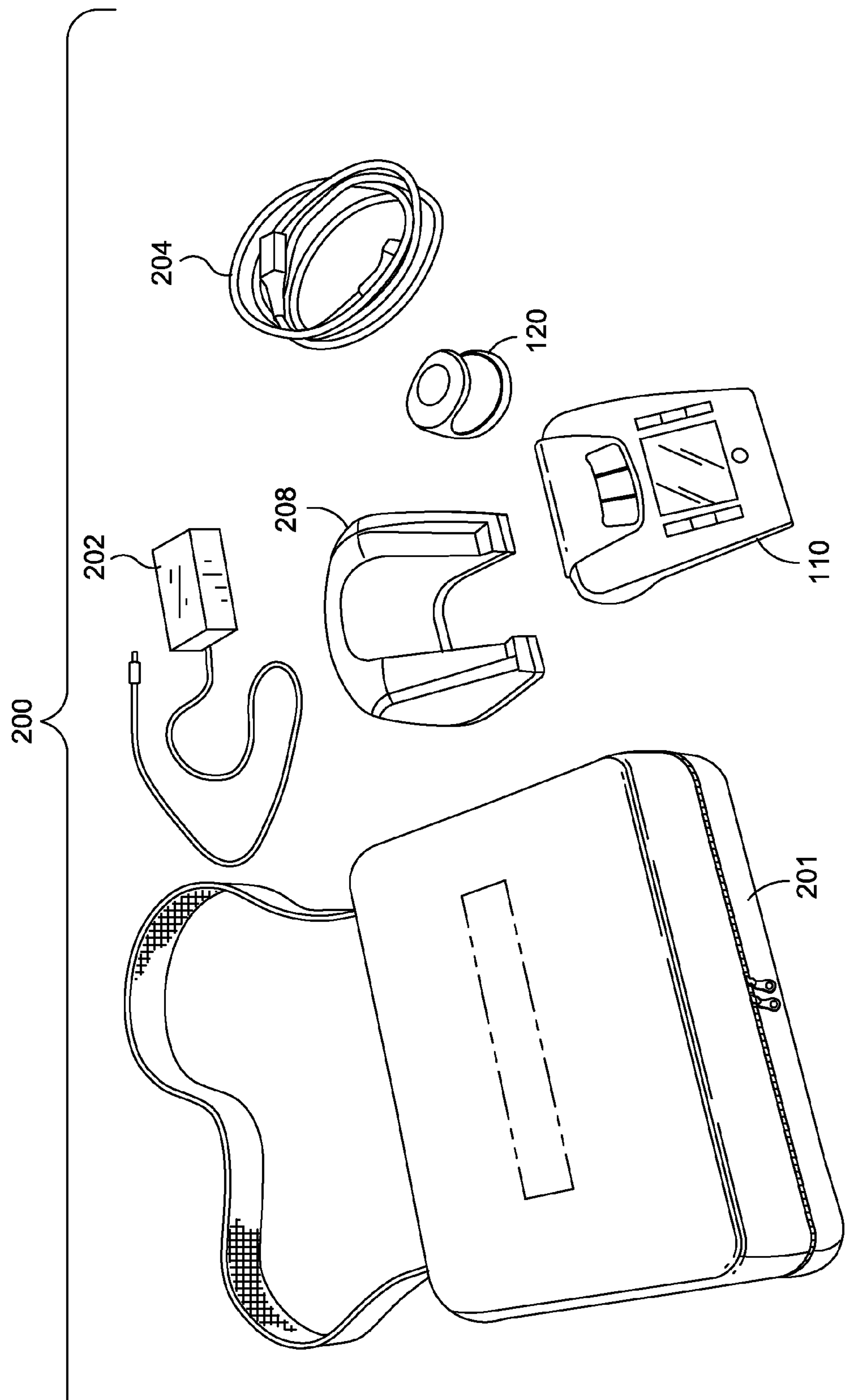
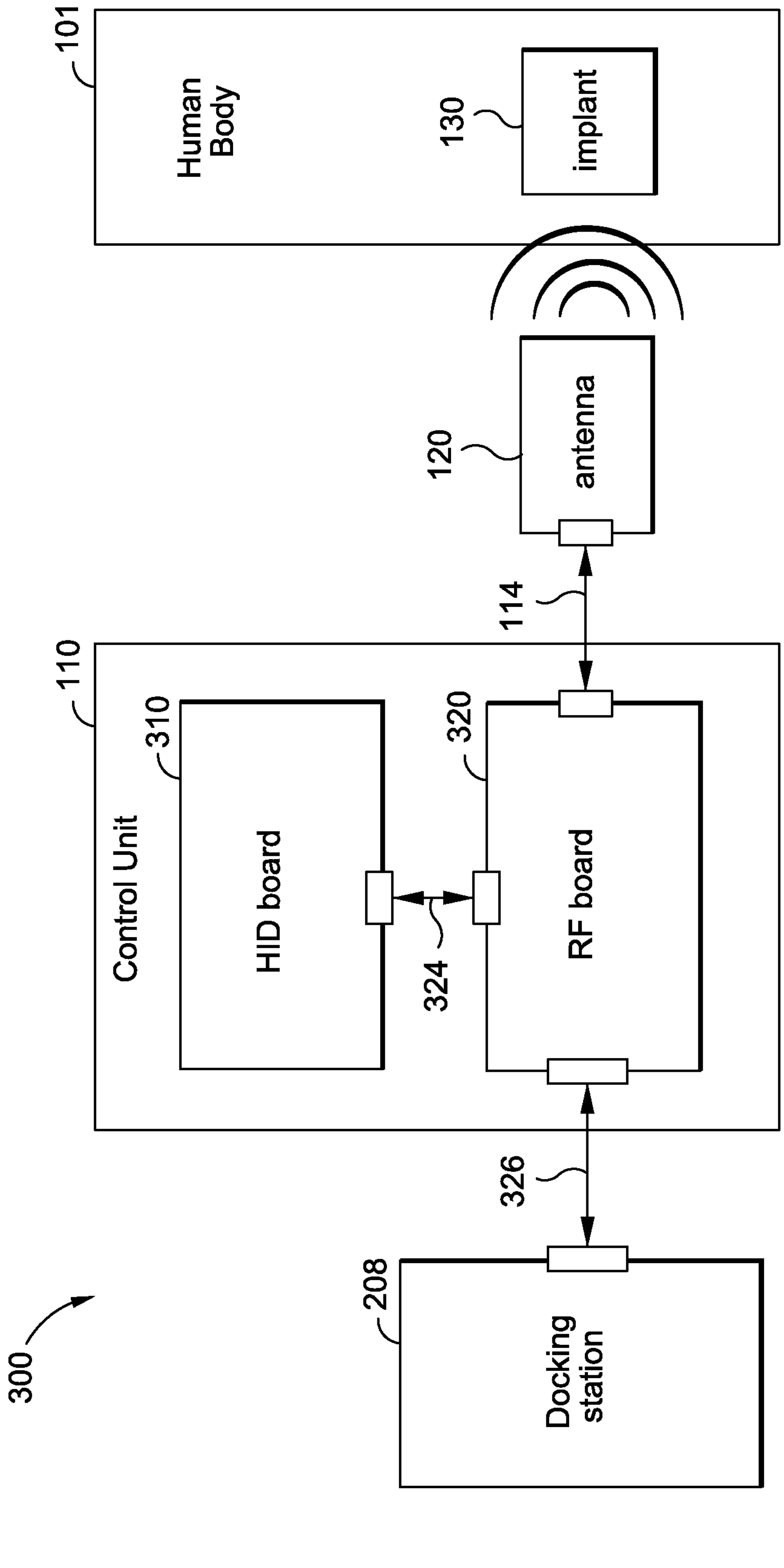


FIG. 2



101
Human Body
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antenna
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110
Control Unit
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HID board
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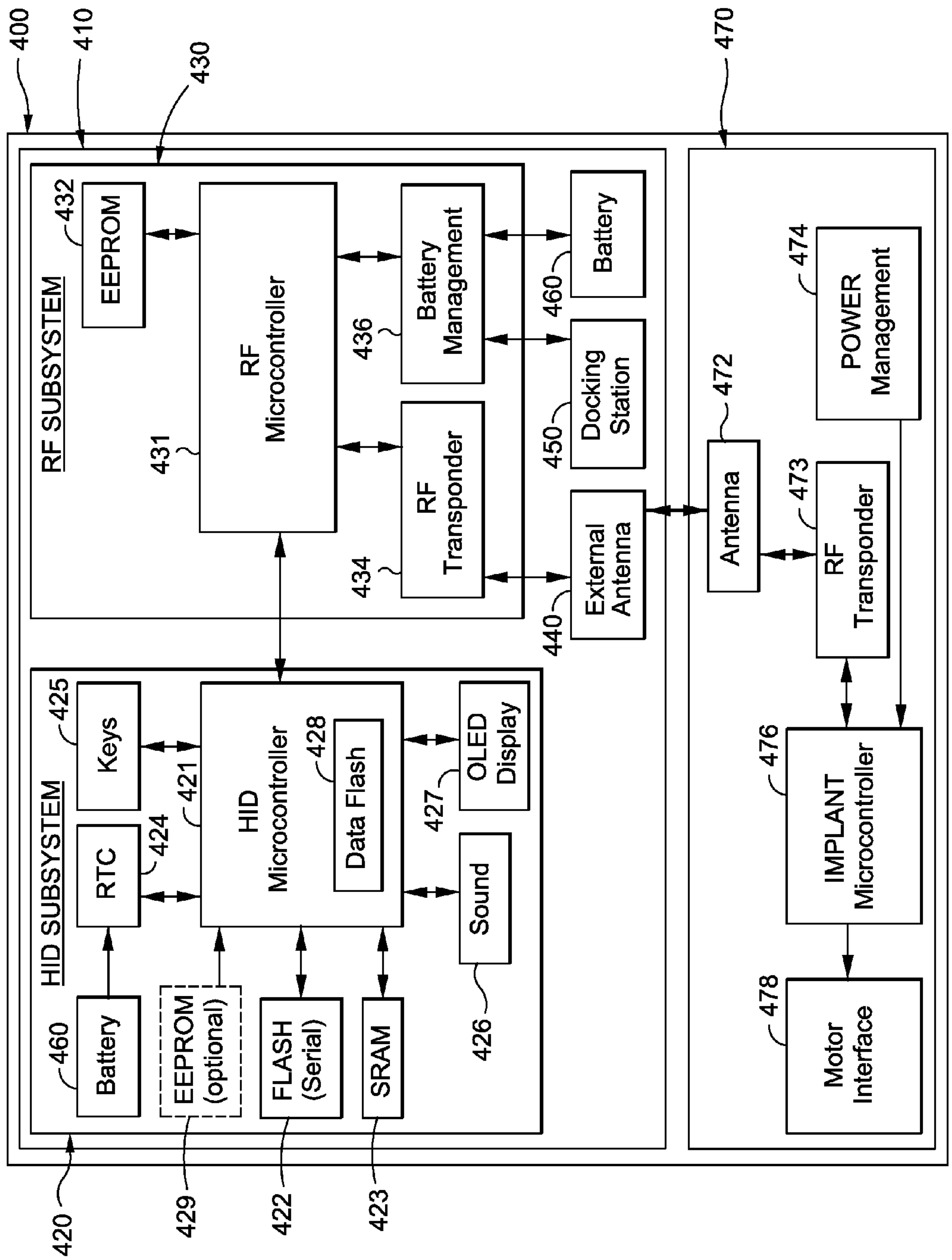
RF board
324
326
208
Docking station
300

FIG. 3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EEPROM
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RF Microcontroller
436
Battery Management
434
RF Transponder
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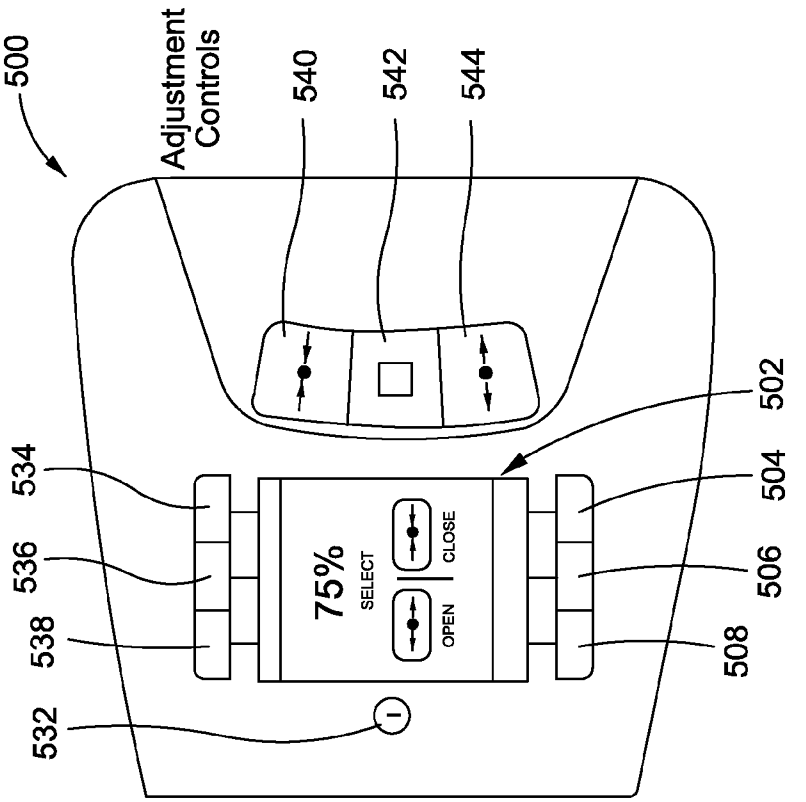
Battery
450
Docking Station
440
External Antenna
472
Antenna
473
RF Transponder
474
POWER Management
476
IMPLANT Microcontroller
478
Motor Interface
HID SUBSYSTEM
425
Keys
424
RTC
421
HID Microcontroller
428
Data Flash
427
OLED Display
Sound
426
460
Battery
EEPROM (optional)
FLASH (Serial)
SRAM
420
429
422
423

FIG. 4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Adjustment Controls
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542
544
534
536
538
532
502
504
506
508
75%
SELECT
OPEN
CLOSE

FIG. 5B

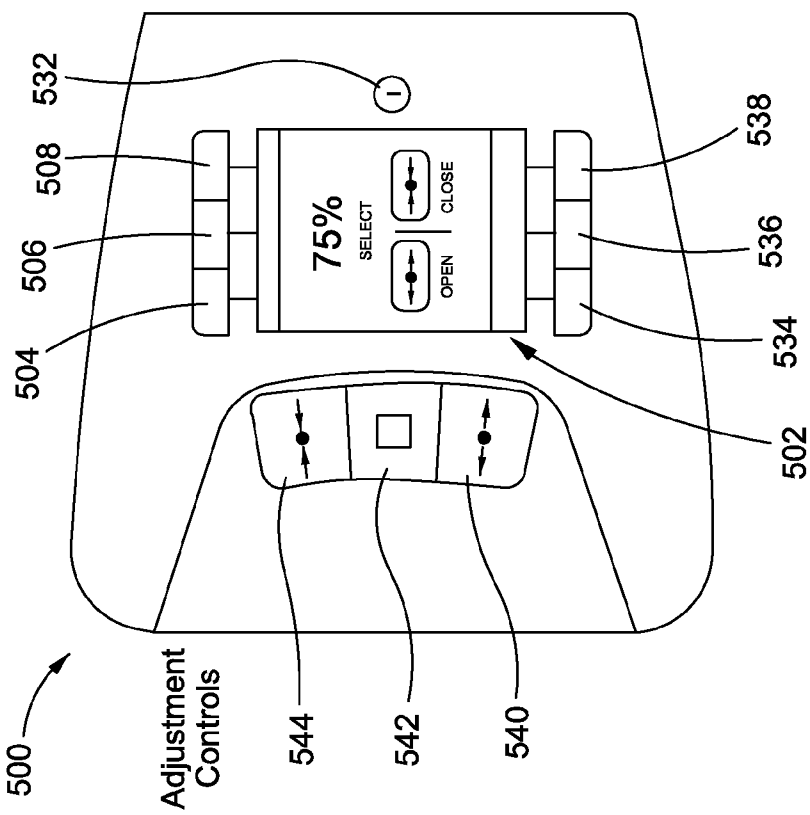
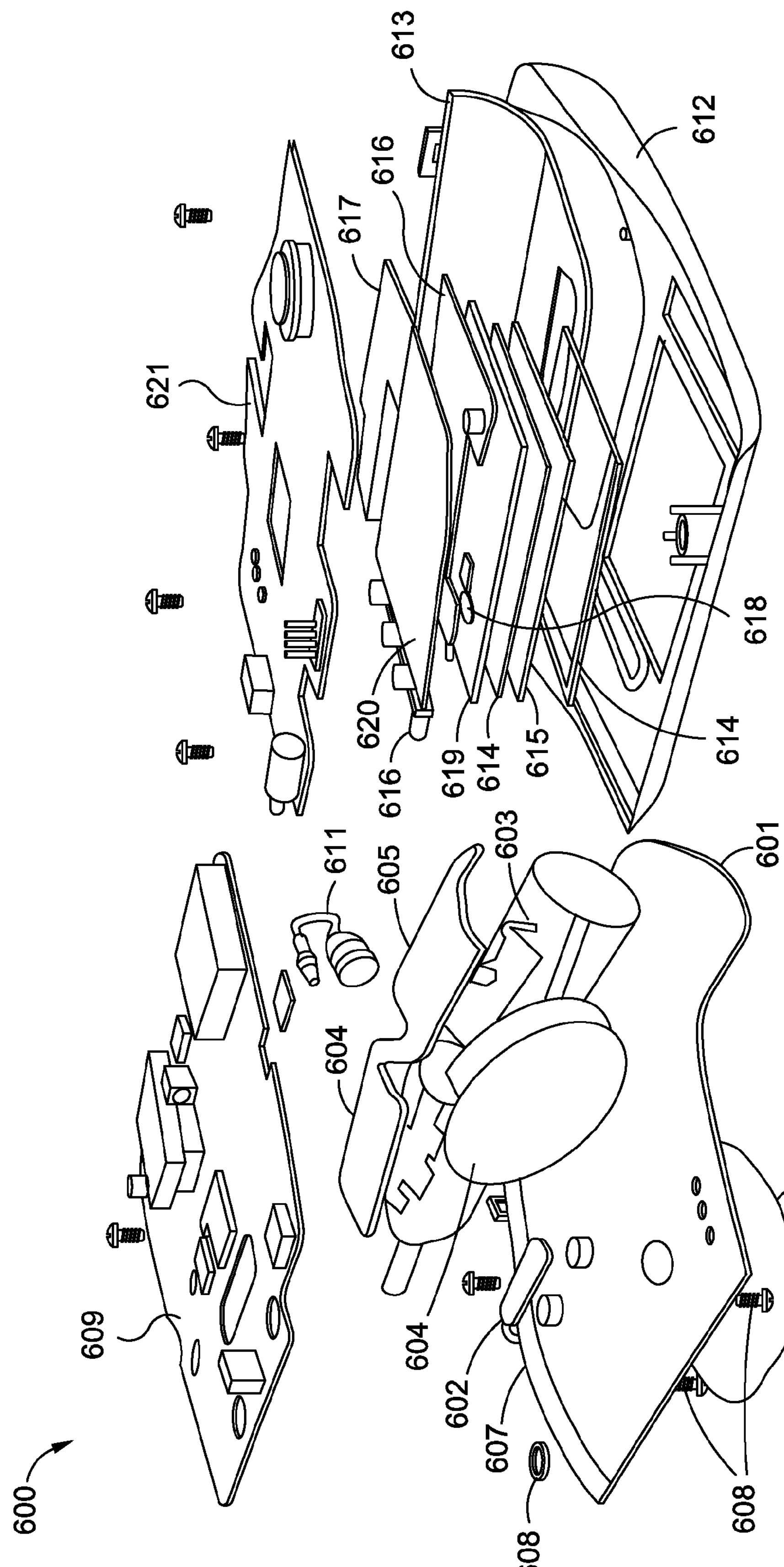

532
508
506
504
538
536
534
502
75%
SELECT
OPEN
CLOSE
500
Adjustment Controls
544
542
540

FIG. 5A



600
601
602
603
604
604
605
607
608
608
608
609
610
611
612
613
614
614
615
616
616
617
618
619
620
621

FIG. 6

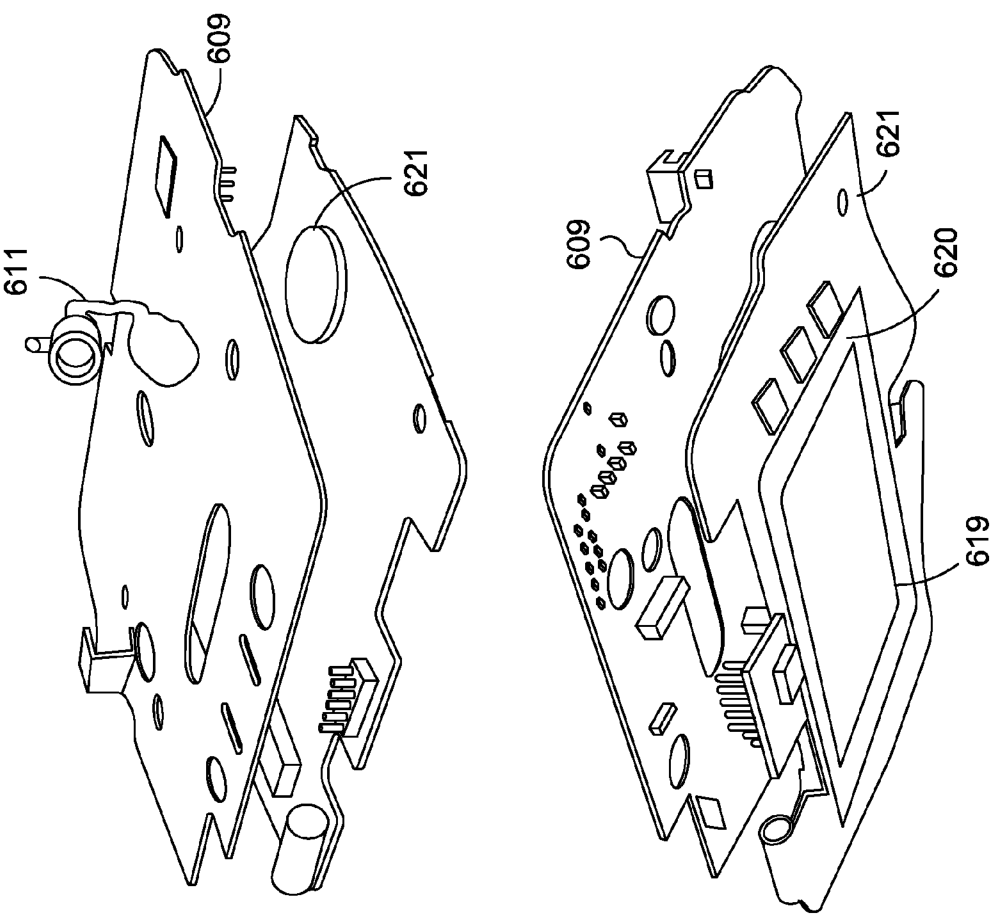


FIG. 7

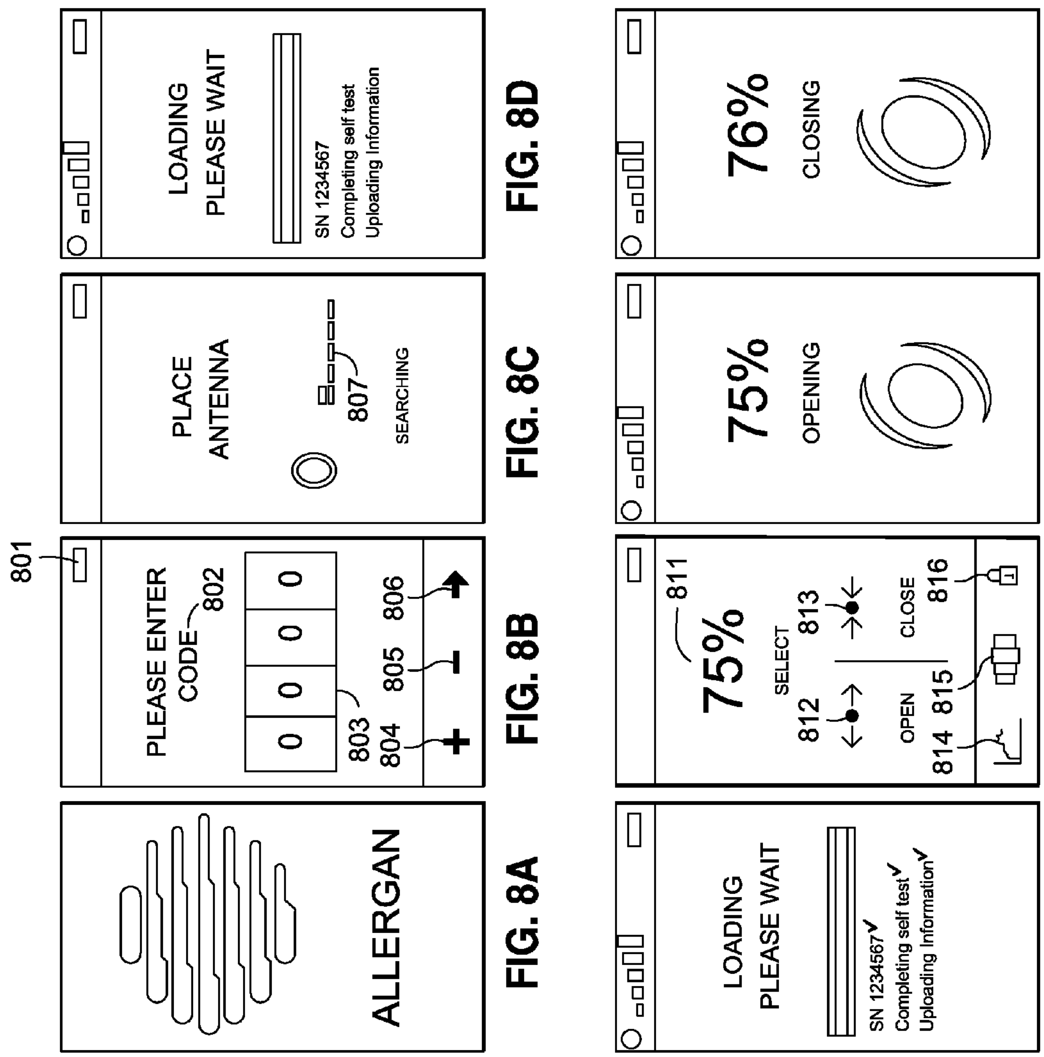


FIG. 8A FIG. 8B FIG. 8C FIG. 8D

FIG. 8E FIG. 8F FIG. 8G FIG. 8H

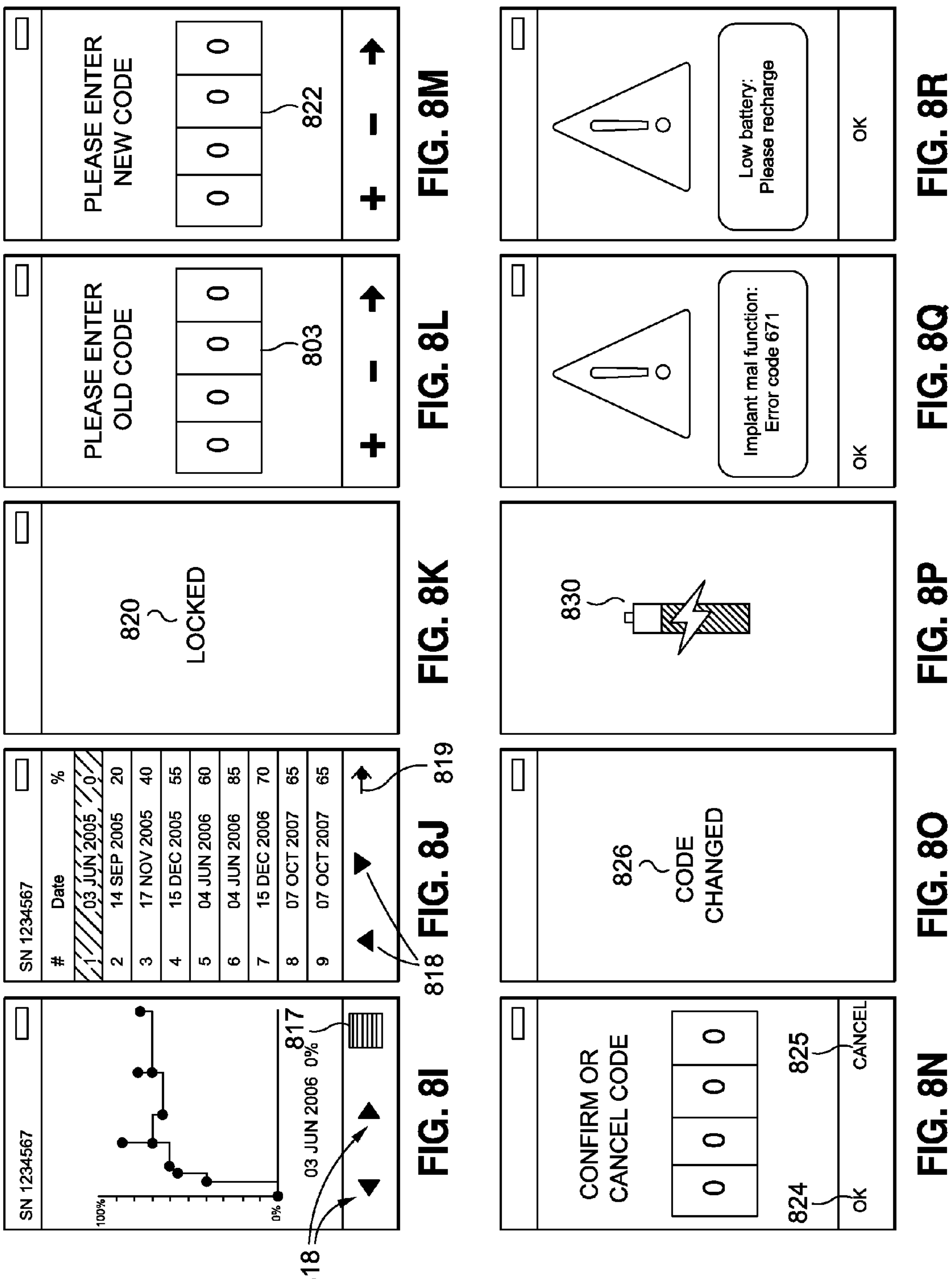


FIG. 8I FIG. 8J FIG. 8K FIG. 8L FIG. 8M

FIG. 8N FIG. 8O FIG. 8P FIG. 8Q FIG. 8R

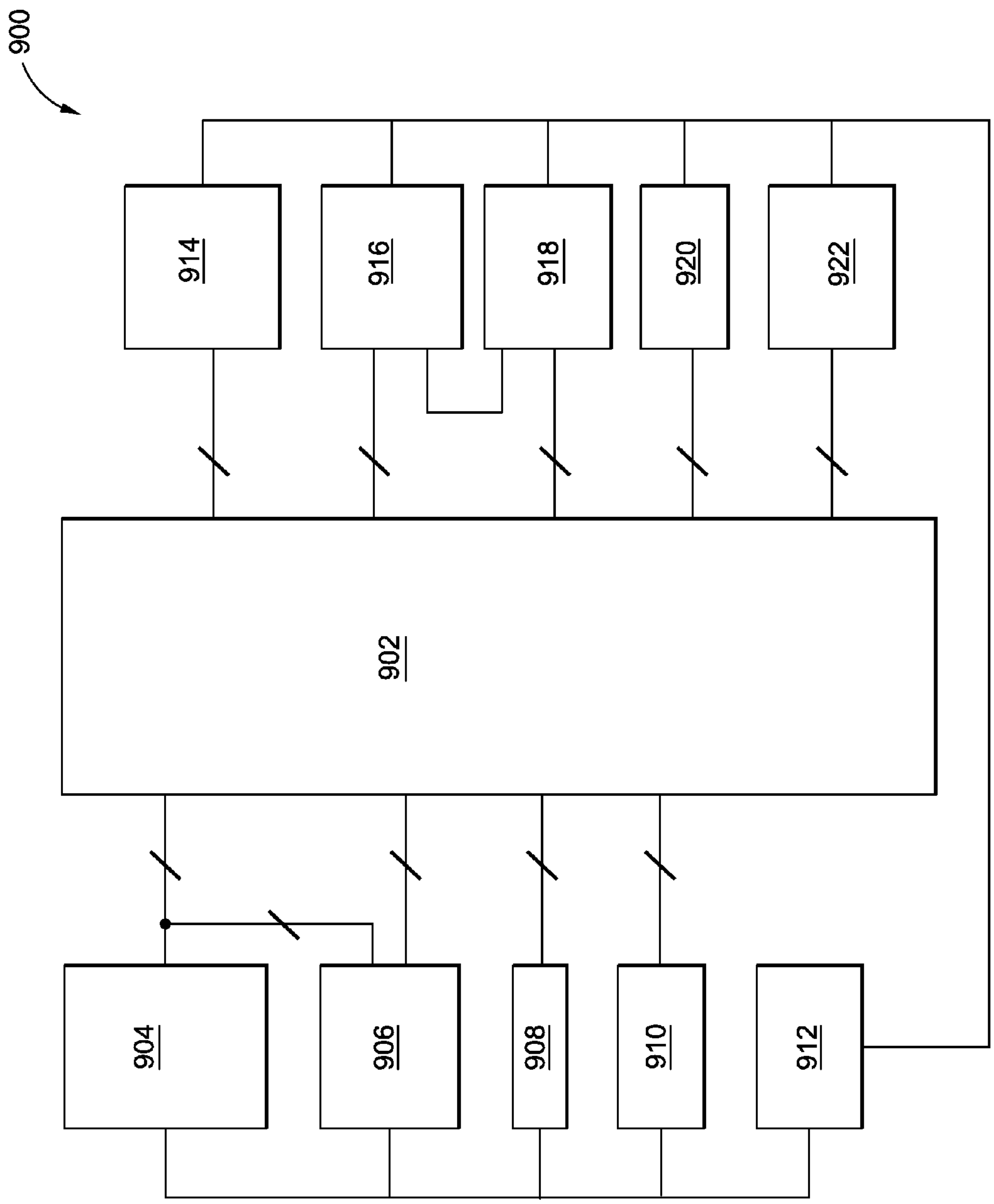


FIG. 9

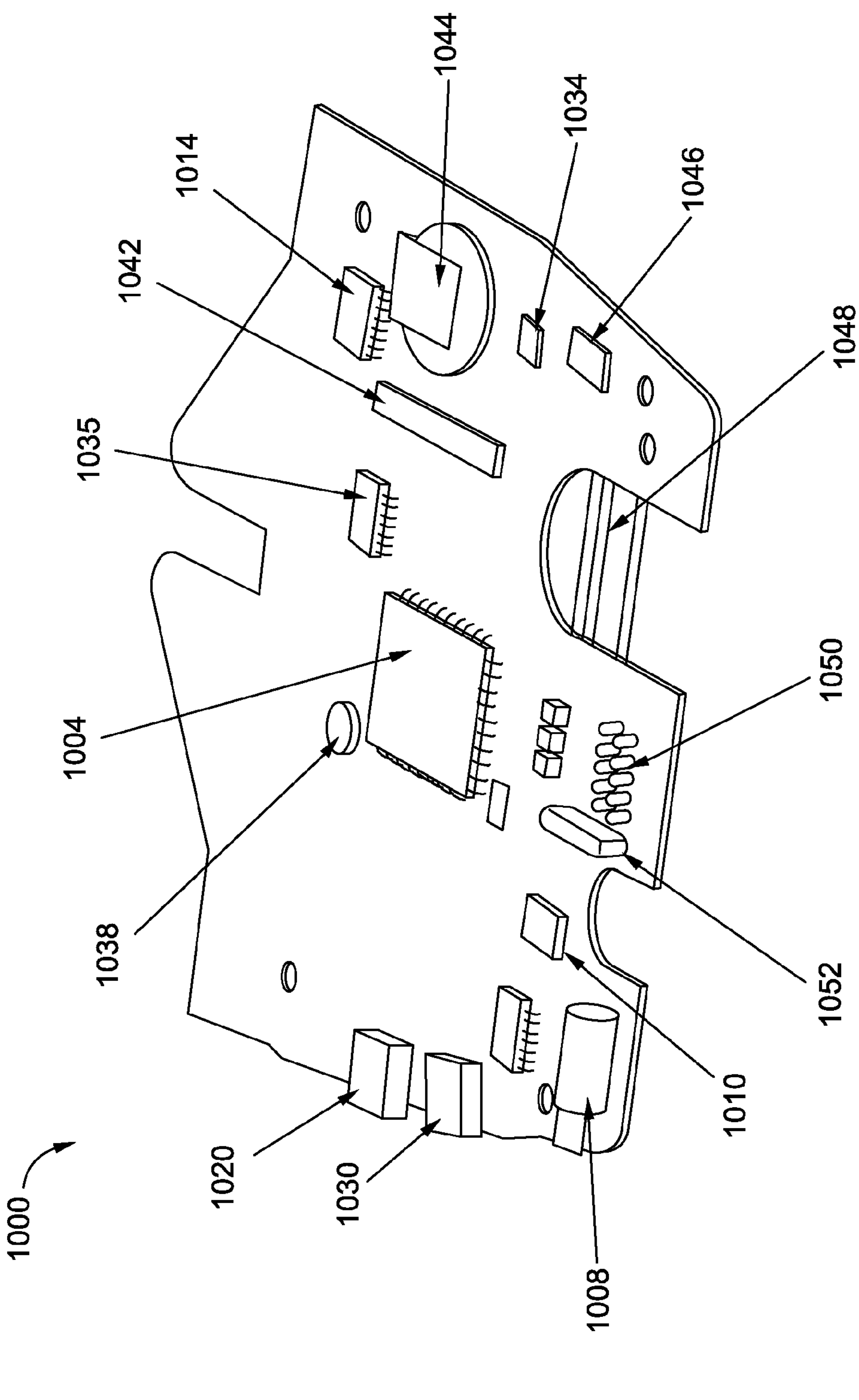

1000
1004
1008
1010
1014
1020
1030
1034
1035
1038
1042
1044
1046
1048
1050
1052

FIG. 10

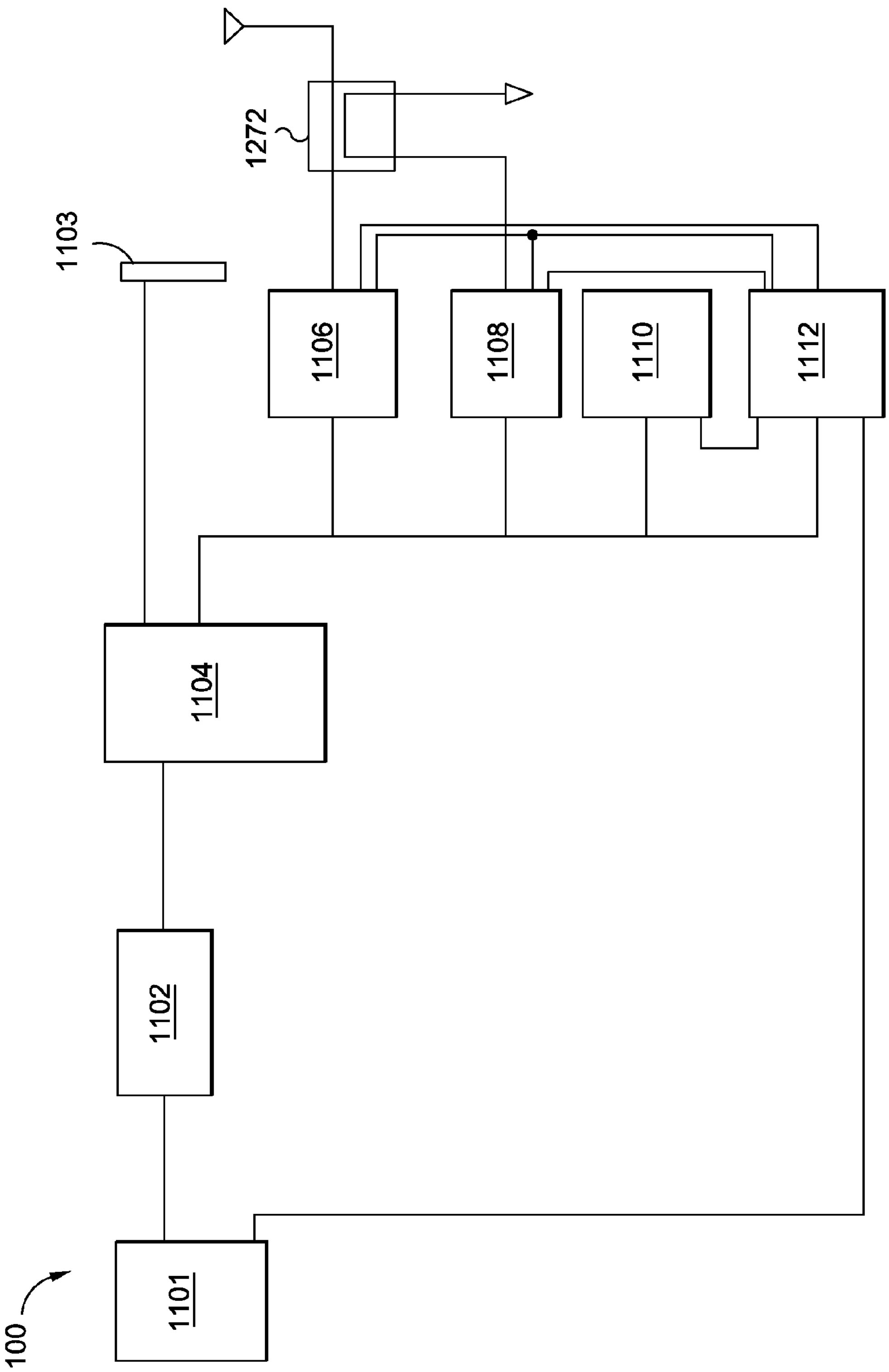


FIG. 11

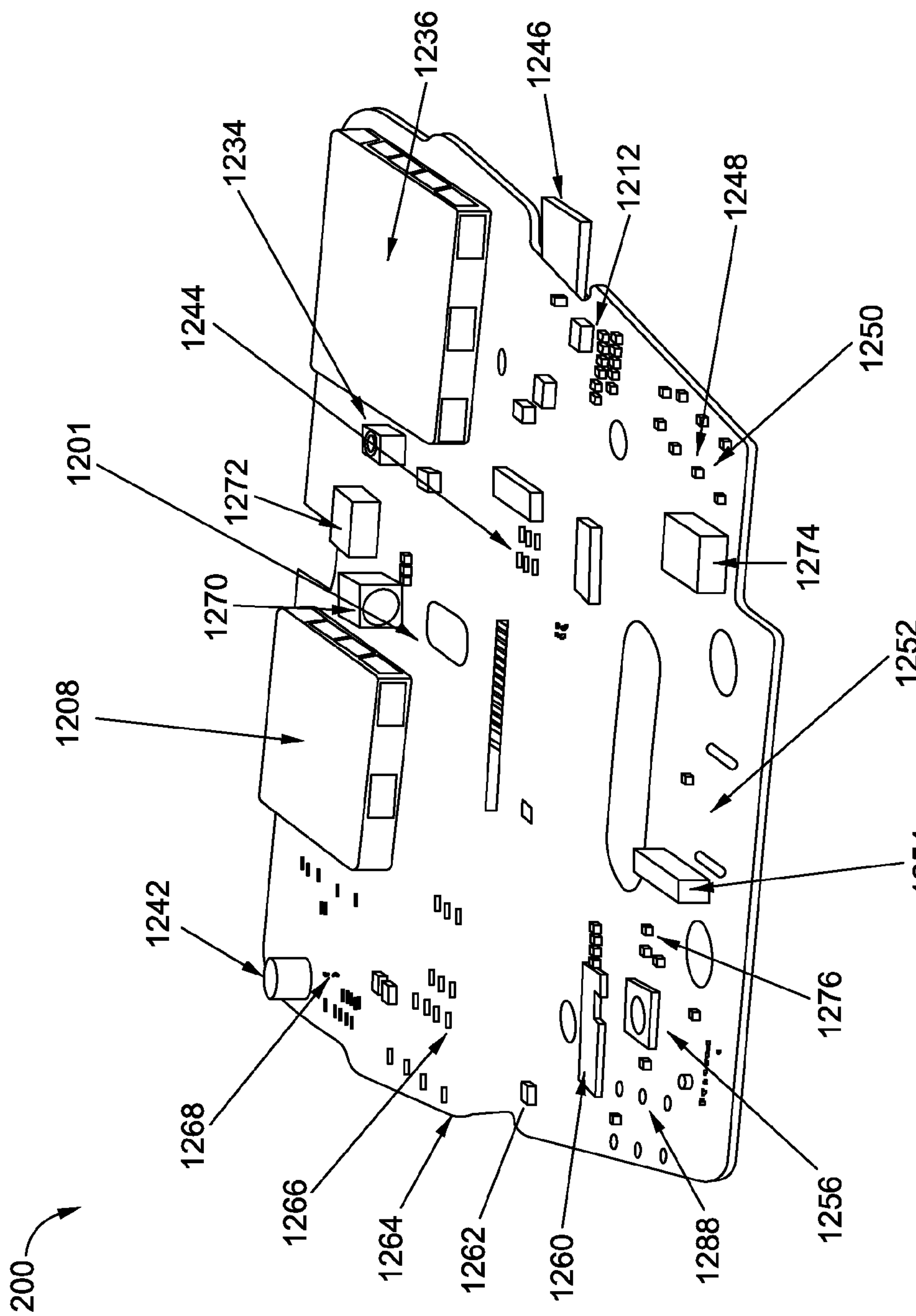
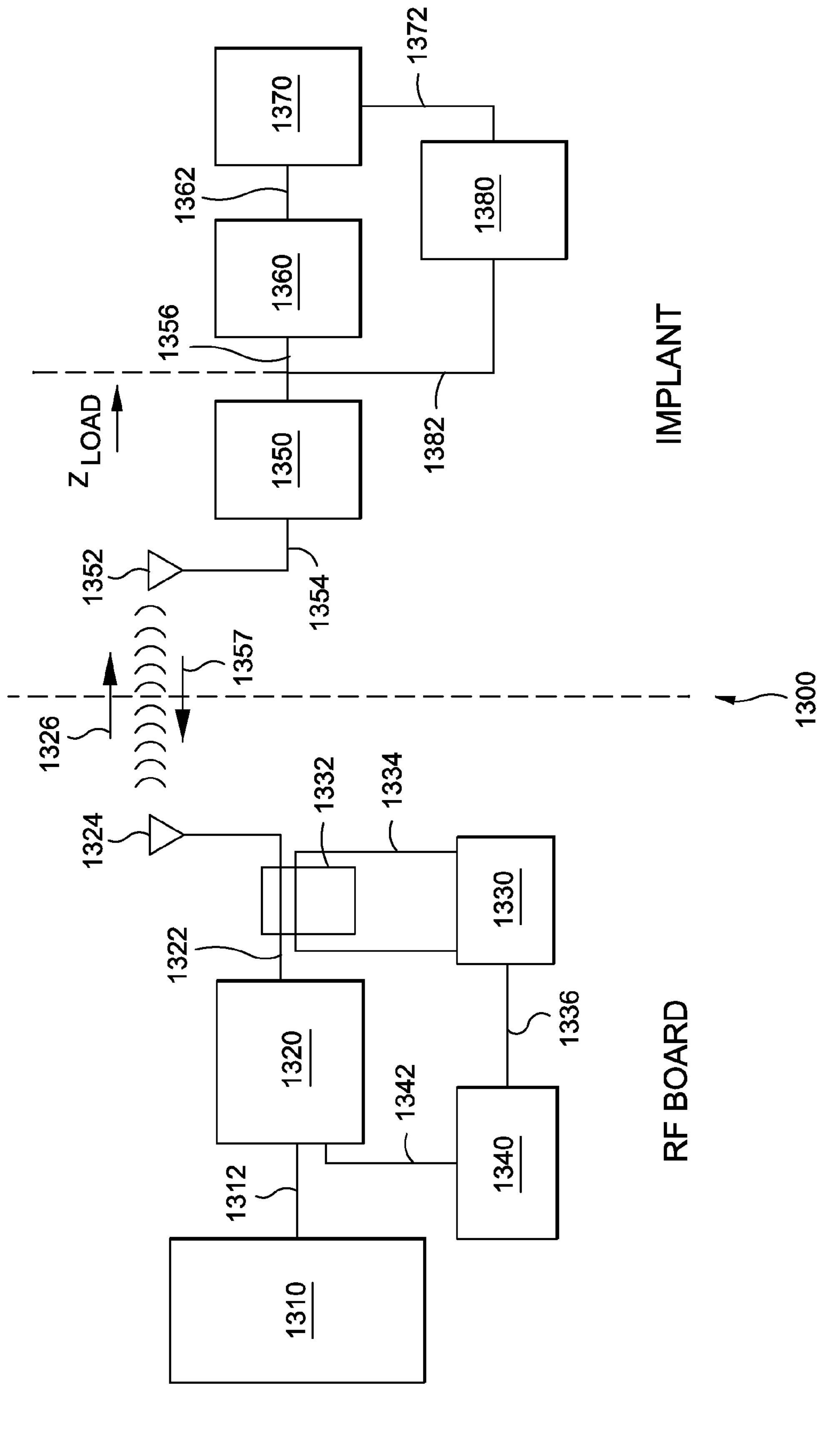

1200
1201
1208
1212
1234
1236
1242
1244
1246
1248
1250
1252
1254
1256
1260
1262
1264
1266
1268
1270
1272
1274
1276
1288

FIG. 12



1310
1312
1320
1322
1324
1326
1330
1332
1334
1336
1340
1342
RF BOARD
1300
1357
1352
1354
1350
1356
1360
1362
1370
1372
1380
1382
Z LOAD
IMPLANT

FIG. 13

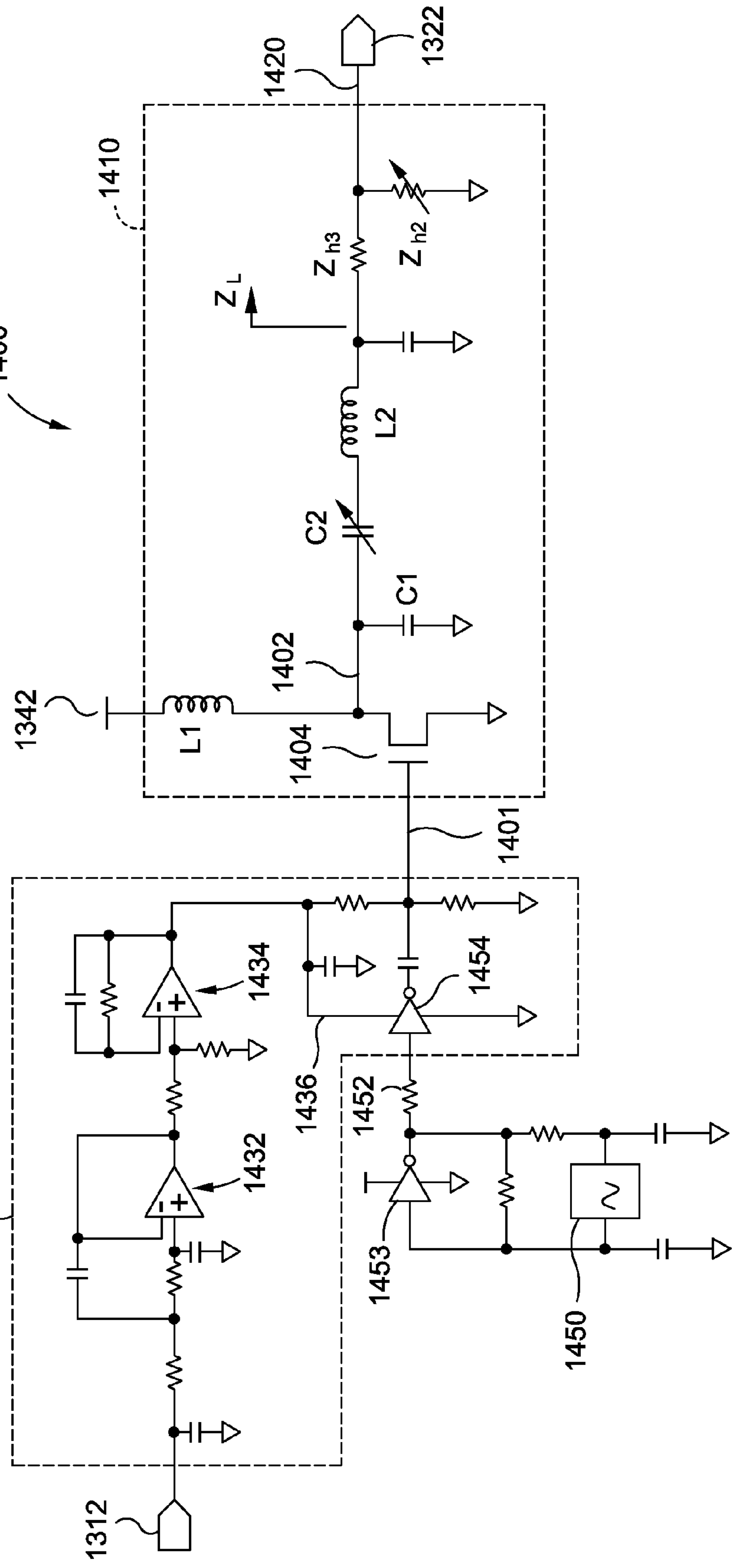

1322
1420
1410
1400
Z_L
Z_{h3}
Z_{h2}
L2
C2
C1
1402
1342
L1
1404
1401
1430
1434
1432
1454
1436
1452
1453
1450
1312

FIG. 14

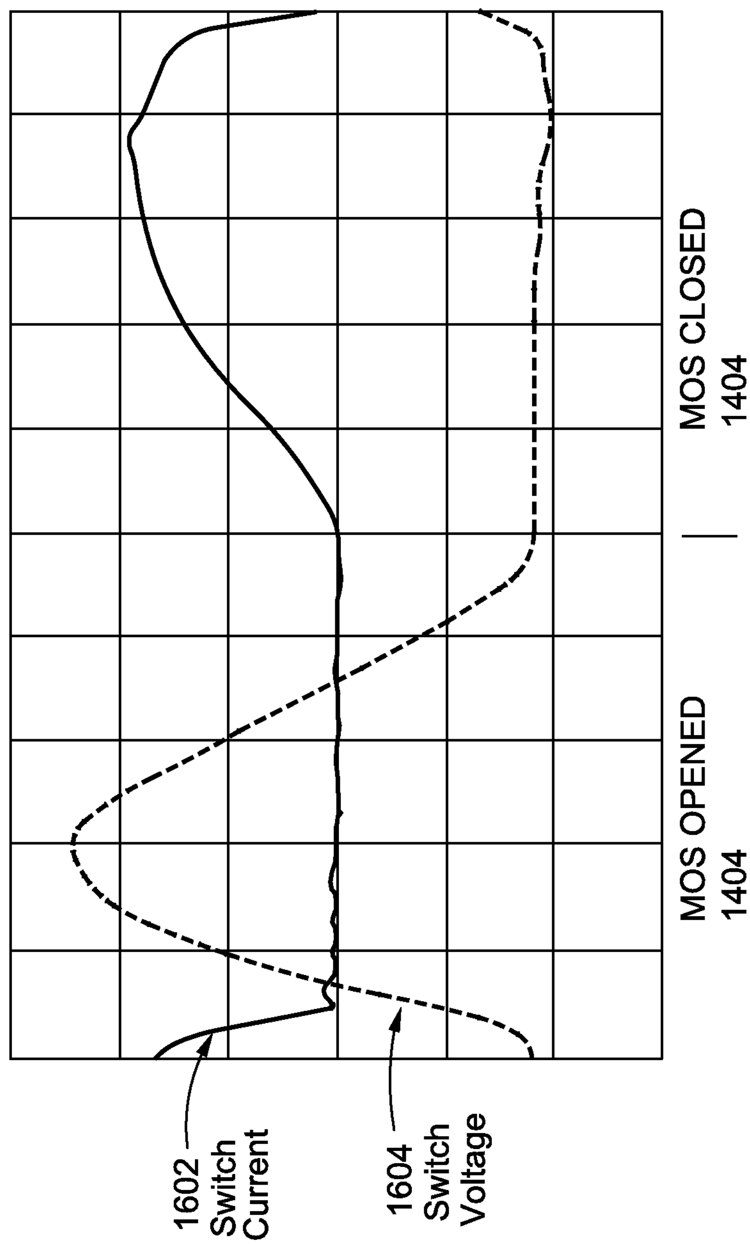

MOS OPENED
1404
MOS CLOSED
1404
1602
Switch
Current
1604
Switch
Voltage

FIG. 15

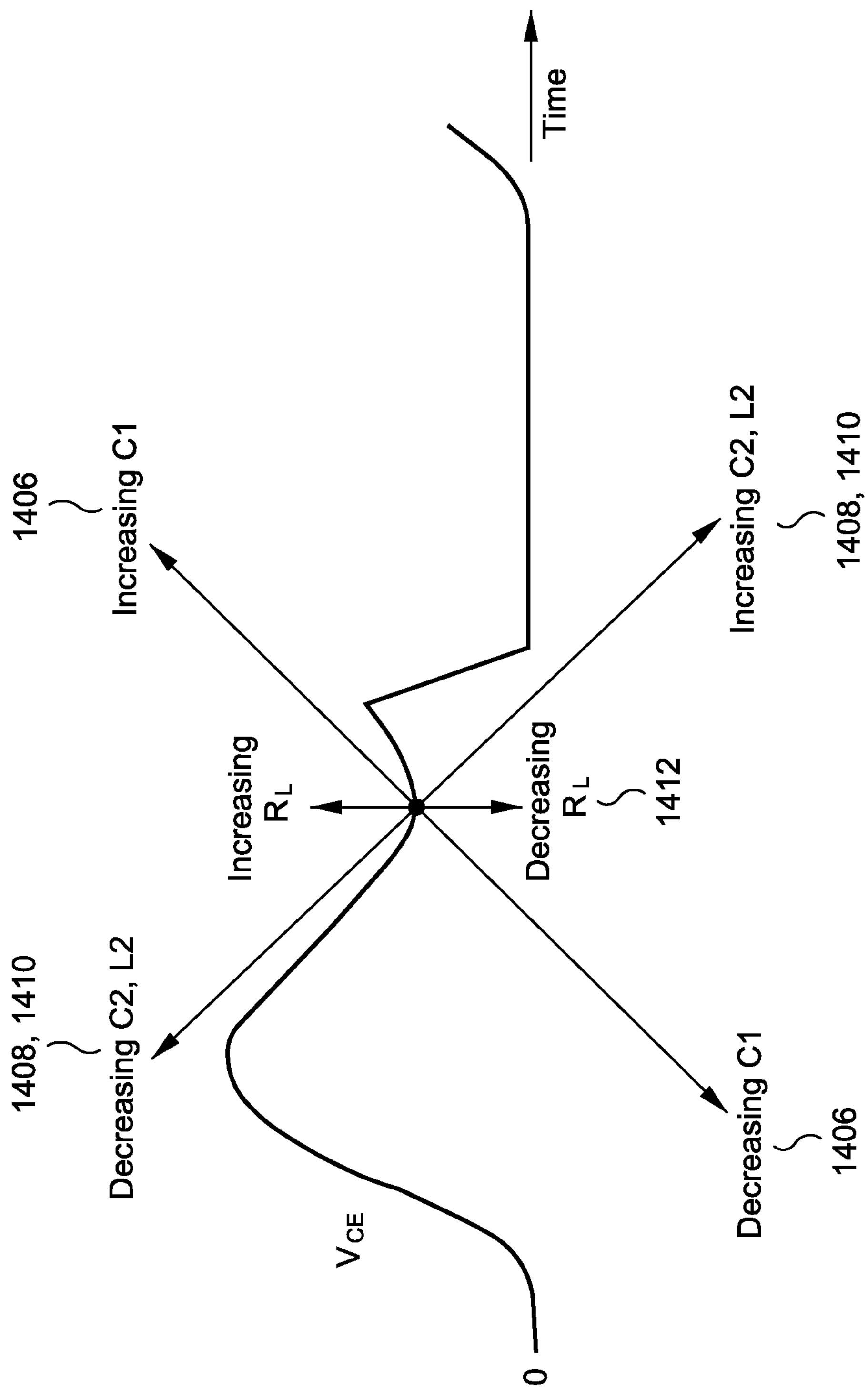

Time
1406
Increasing C1
Increasing C2, L2
1408, 1410
Increasing
R L
Decreasing
R L
1412
1408, 1410
Decreasing C2, L2
Decreasing C1
1406
V CE
0

FIG. 16

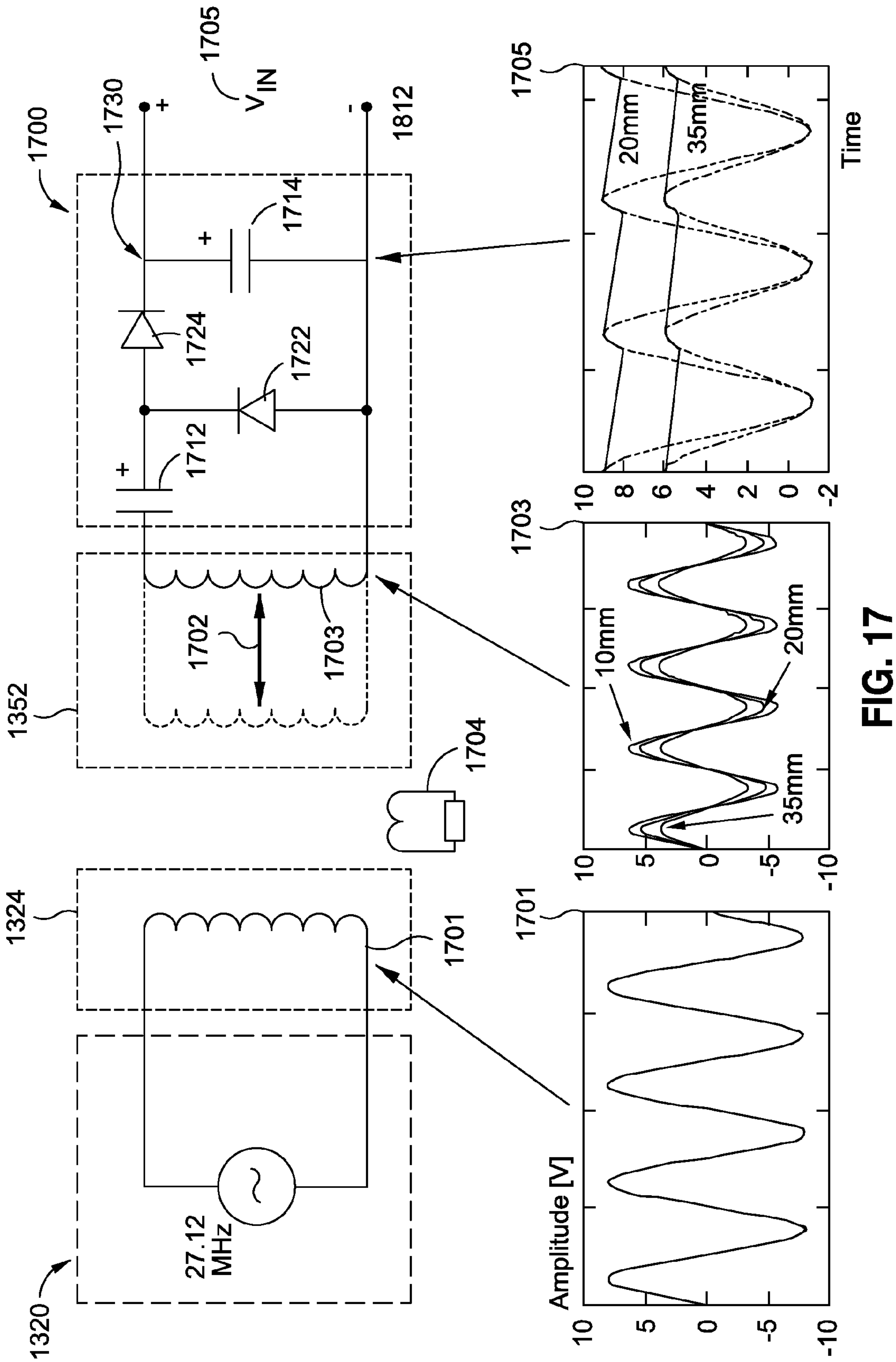

1700
1730
1705
V_{IN}
1812
1714
1724
1722
1712
1352
1702
1703
1704
1324
1701
1320
27.12 MHz
Amplitude [V]
Time
10mm
20mm
35mm

FIG. 17

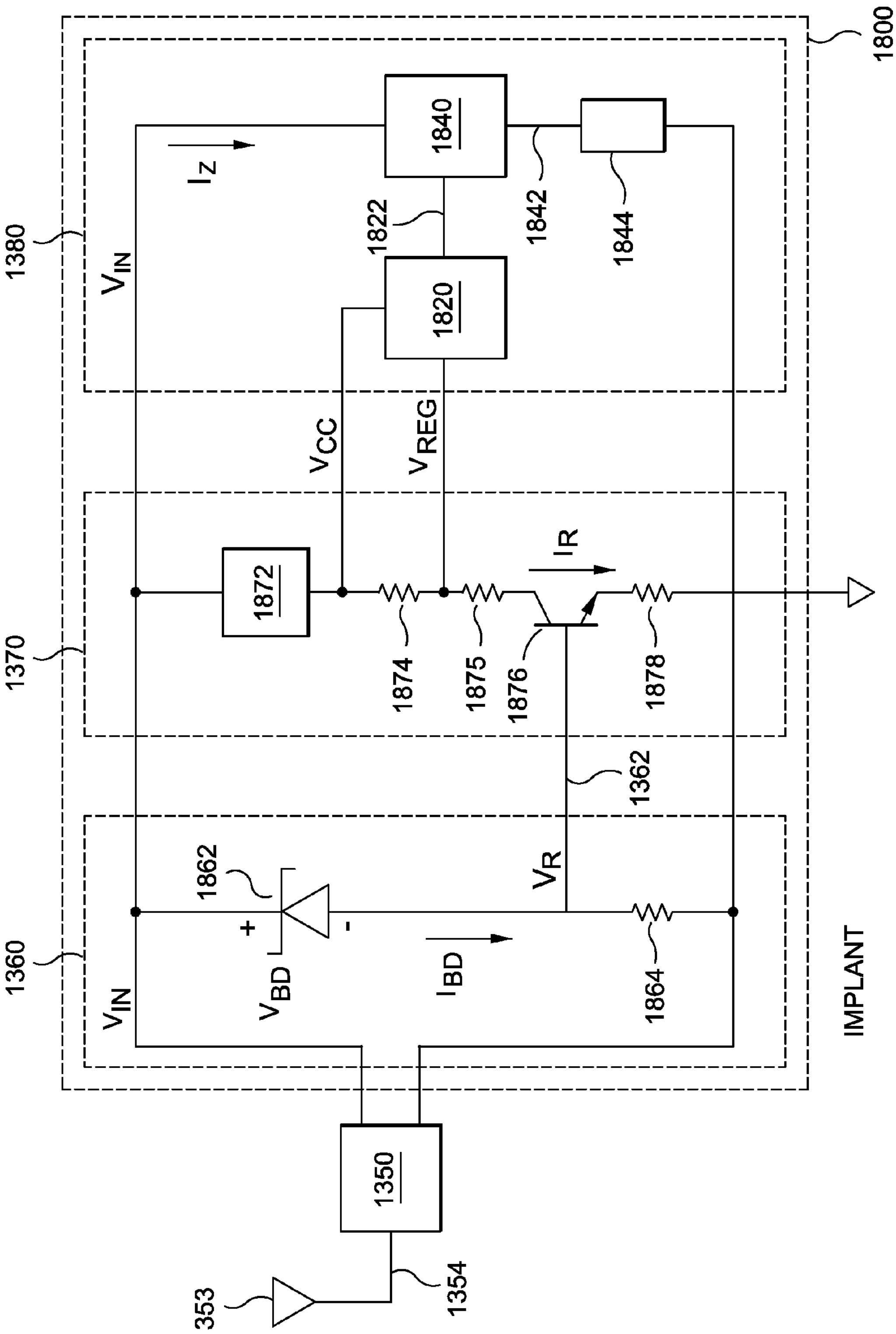

1800
1380
1370
1360
1840
1820
1844
1842
1822
I_Z
V_{IN}
V_{CC}
V_{REG}
1872
1874
1875
1876
1878
I_R
1362
V_R
1862
+
-
V_{BD}
I_{BD}
1864
IMPLANT
1350
1353
1354

FIG. 18

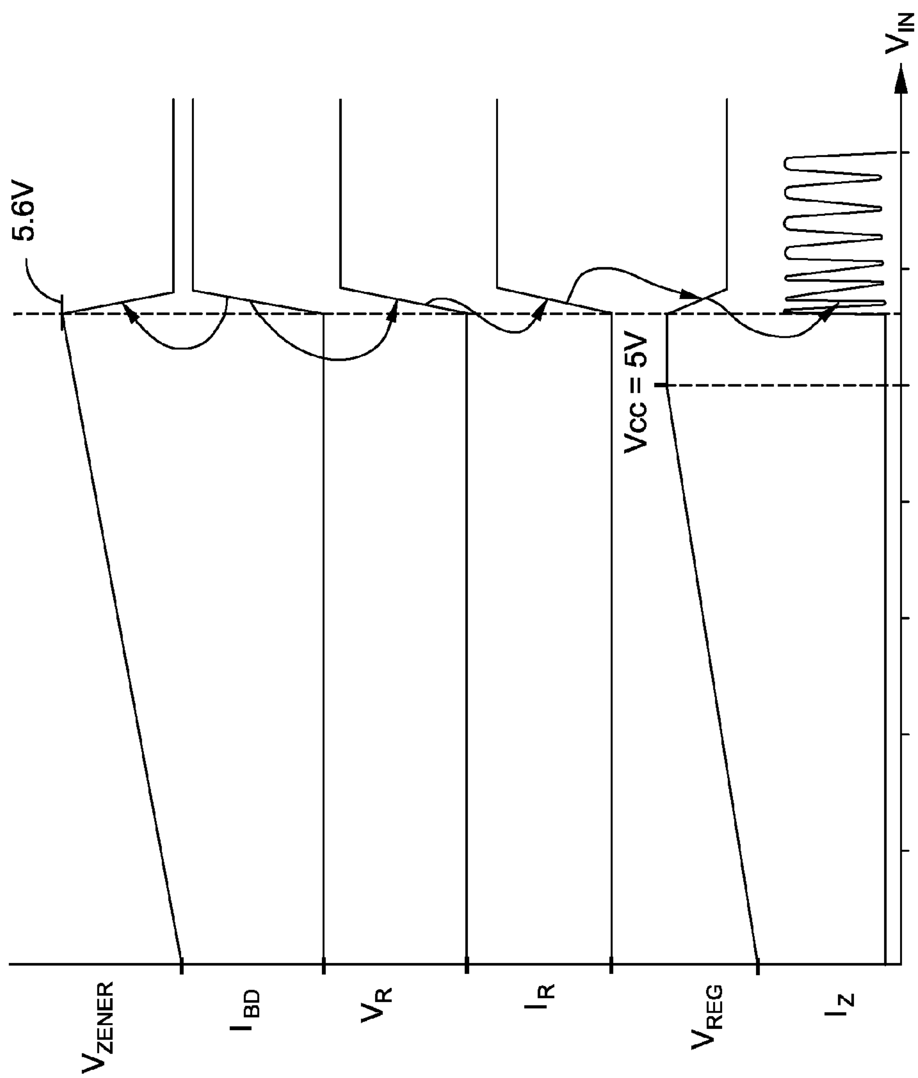


FIG. 19

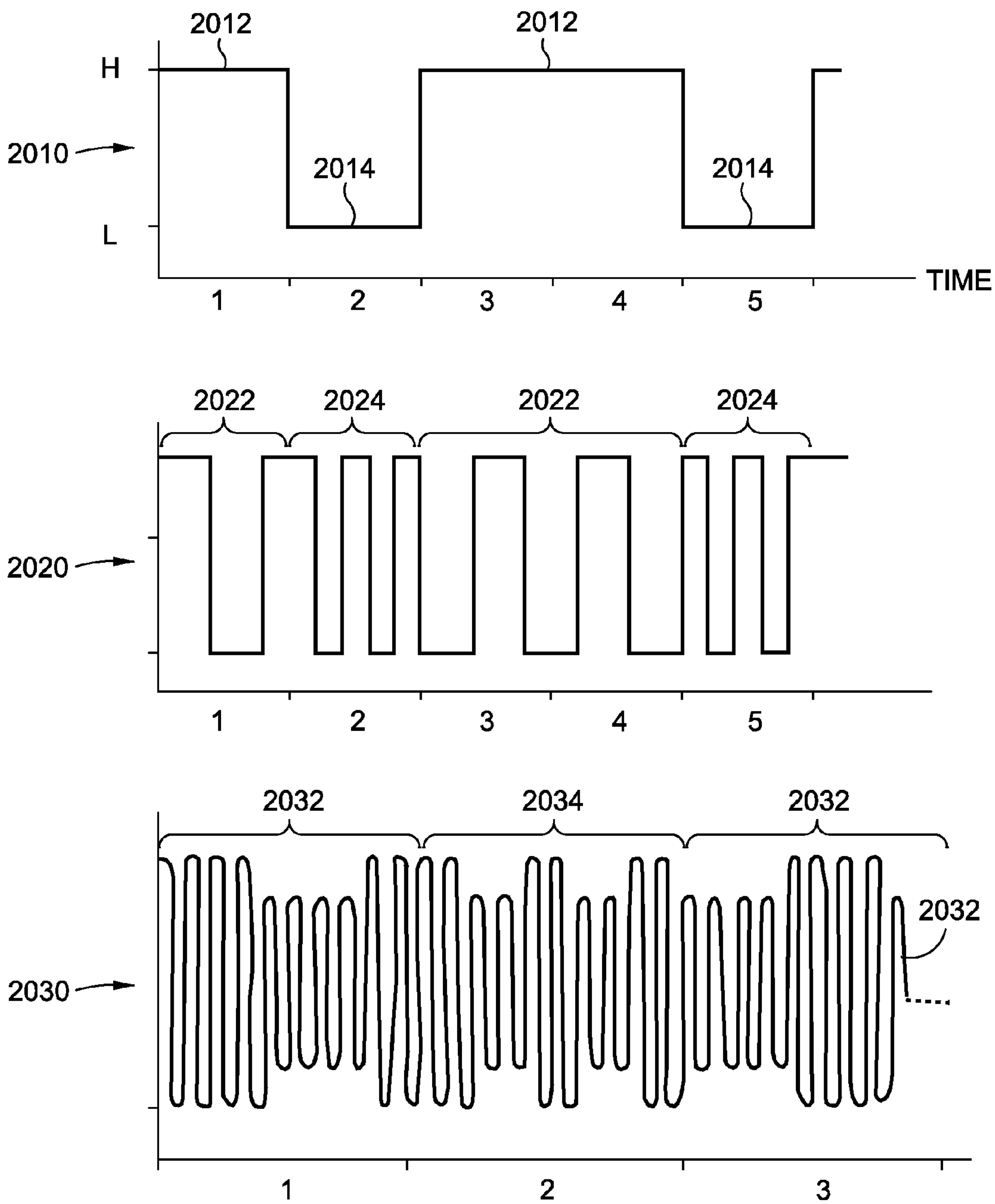
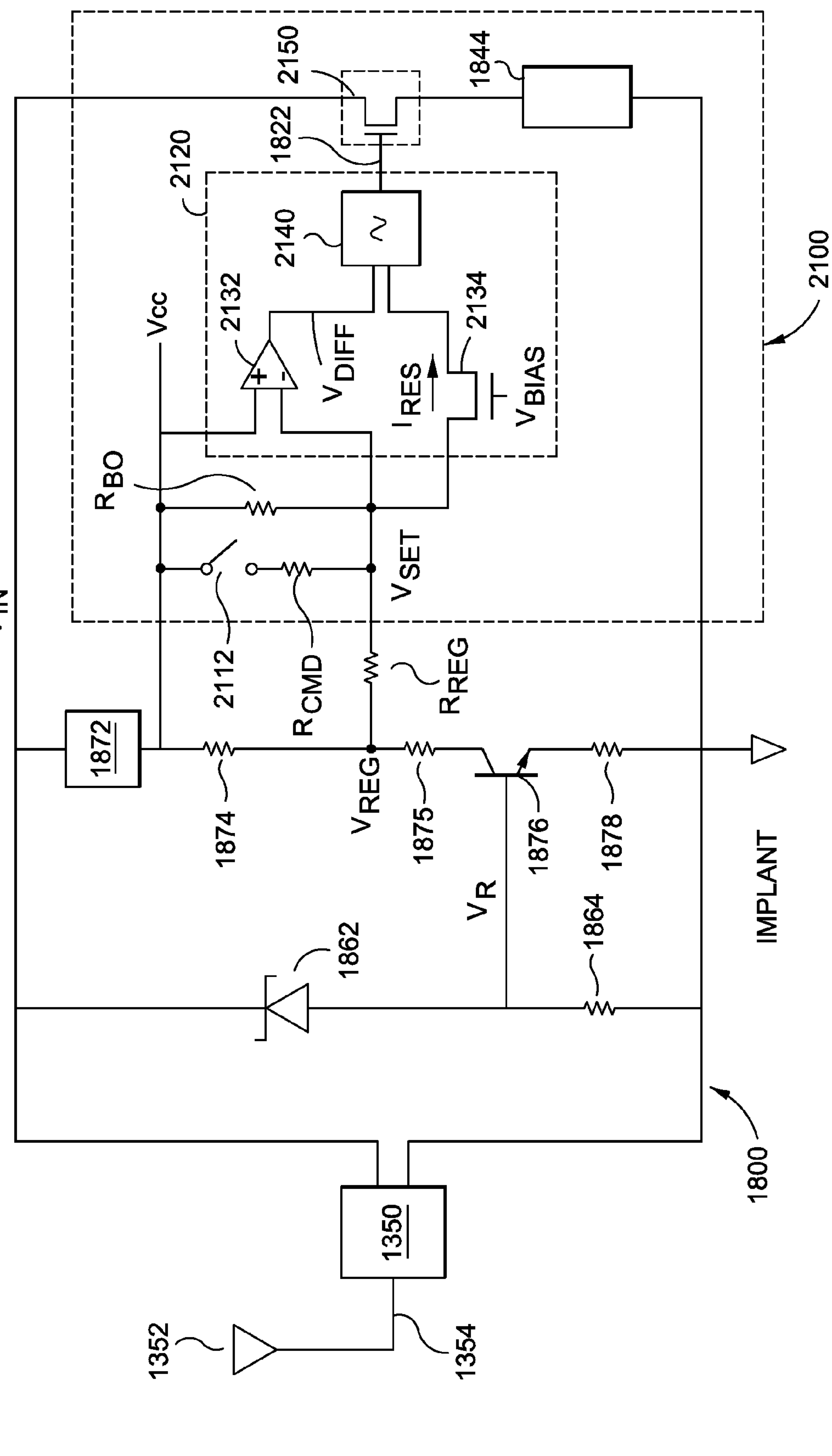

2012
2012
H
2010
2014
2014
L
TIME
1
2
3
4
5
2022
2024
2022
2024
2020
1
2
3
4
5
2032
2034
2032
2032
2030
1
2
3

FIG. 20



2150
1844
1822
2120
2140
2100
2132
2134
Vcc
V_{DIFF}
I_{RES}
V_{BIAS}
R_{BO}
V_{SET}
V_{IN}
2112
R_{CMD}
R_{REG}
1872
1874
V_{REG}
1875
1876
1878
V_R
1864
1862
IMPLANT
1800
1350
1352
1354

FIG. 21

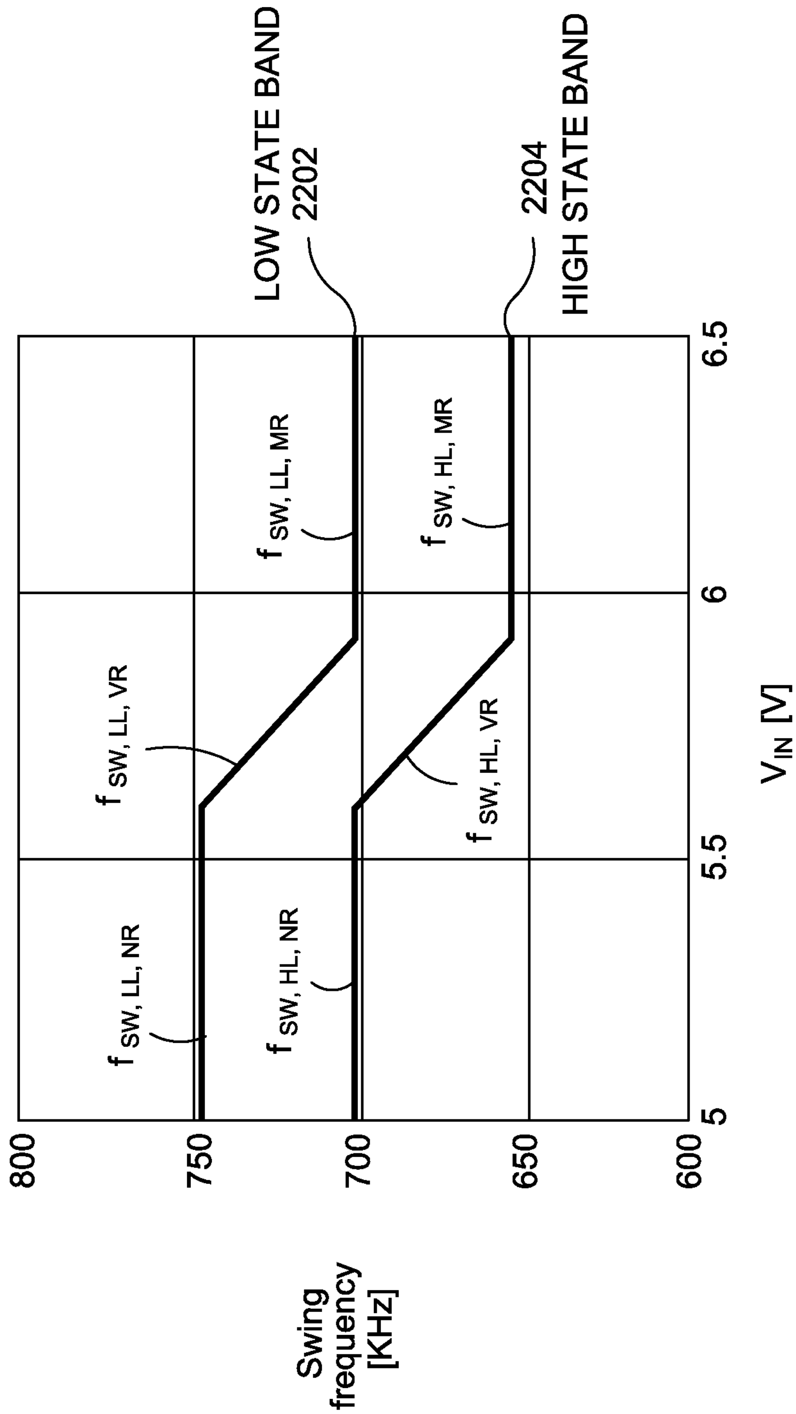

LOW STATE BAND
2202
2204
HIGH STATE BAND
Swing
frequency
[KHz]
800
750
700
650
600
5
5.5
6
6.5
V_{IN} [V]
$f_{SW,\,LL,\,NR}$
$f_{SW,\,HL,\,NR}$
$f_{SW,\,LL,\,VR}$
$f_{SW,\,HL,\,VR}$
$f_{SW,\,LL,\,MR}$
$f_{SW,\,HL,\,MR}$

FIG. 22

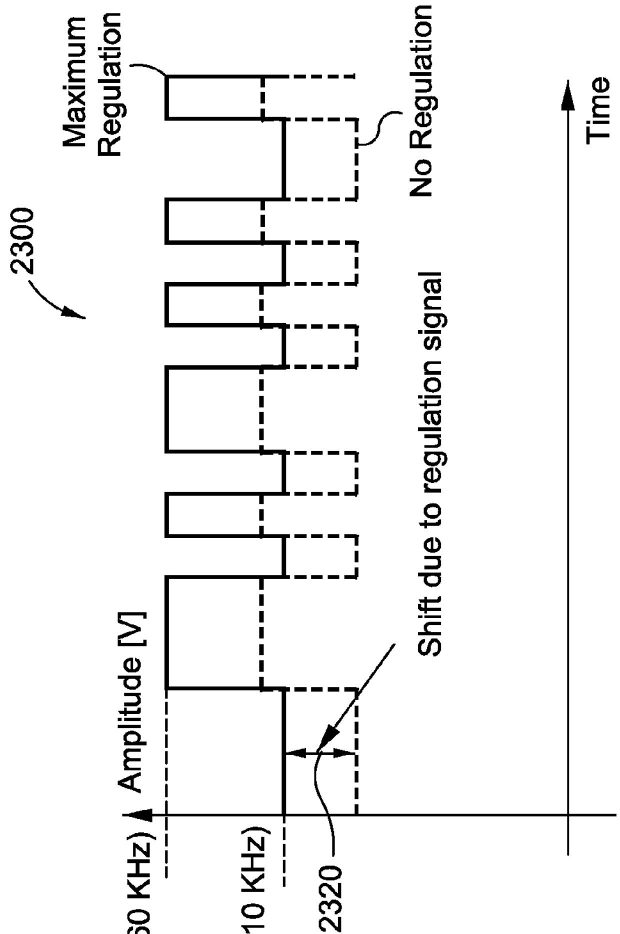


FIG. 23B

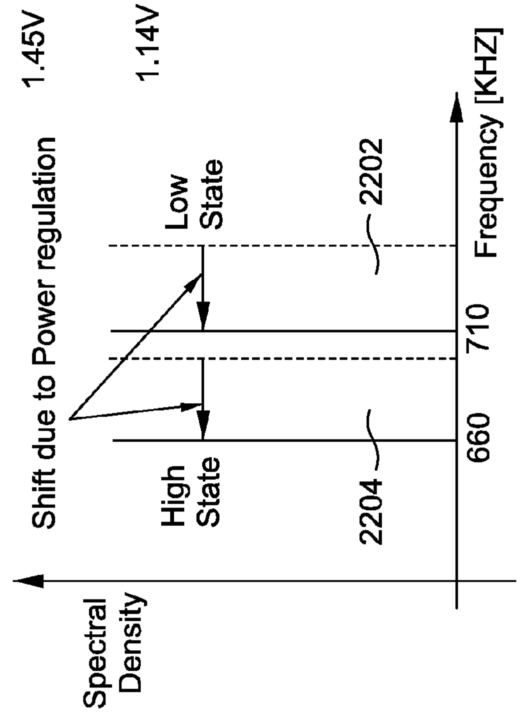


FIG. 23A

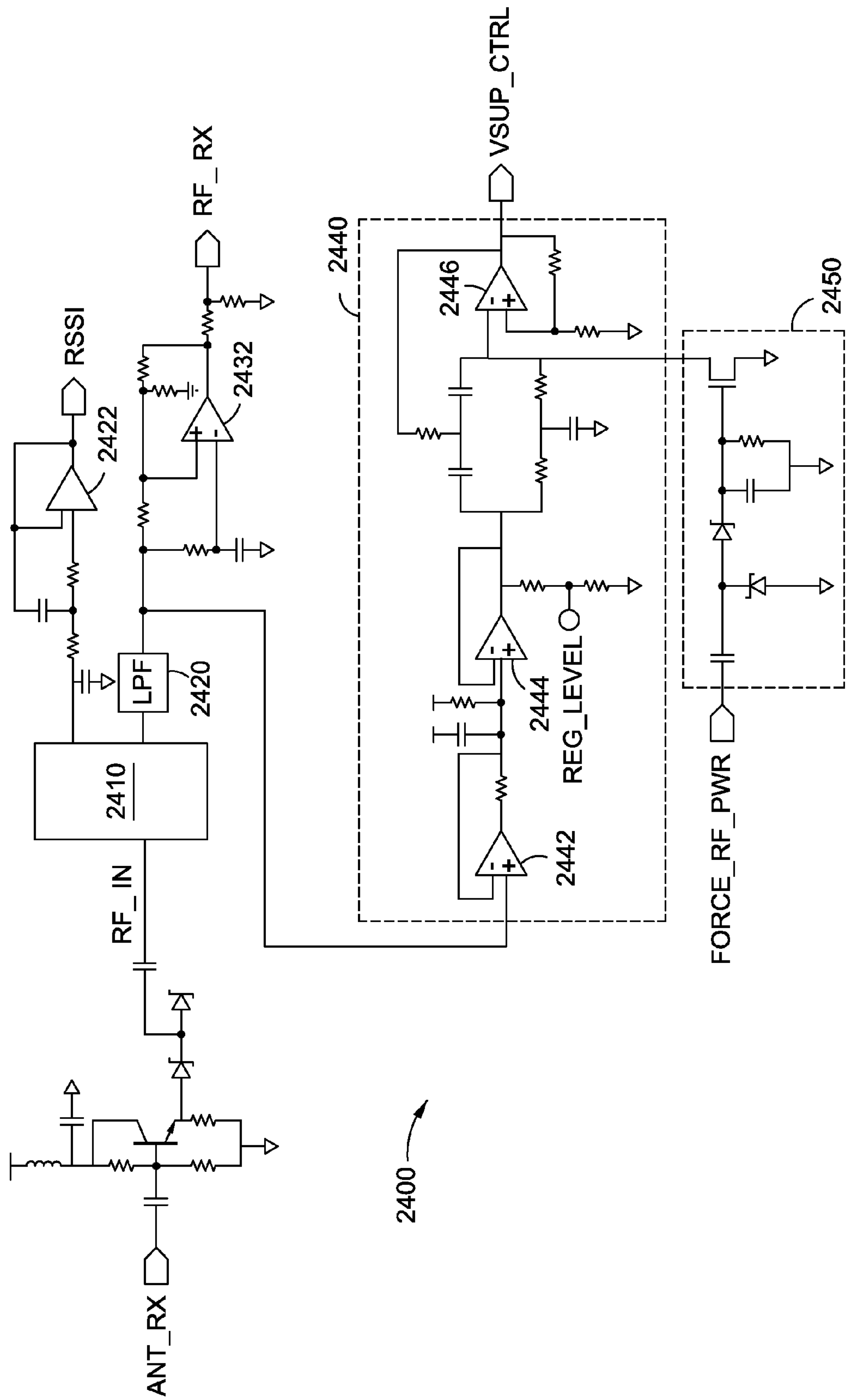
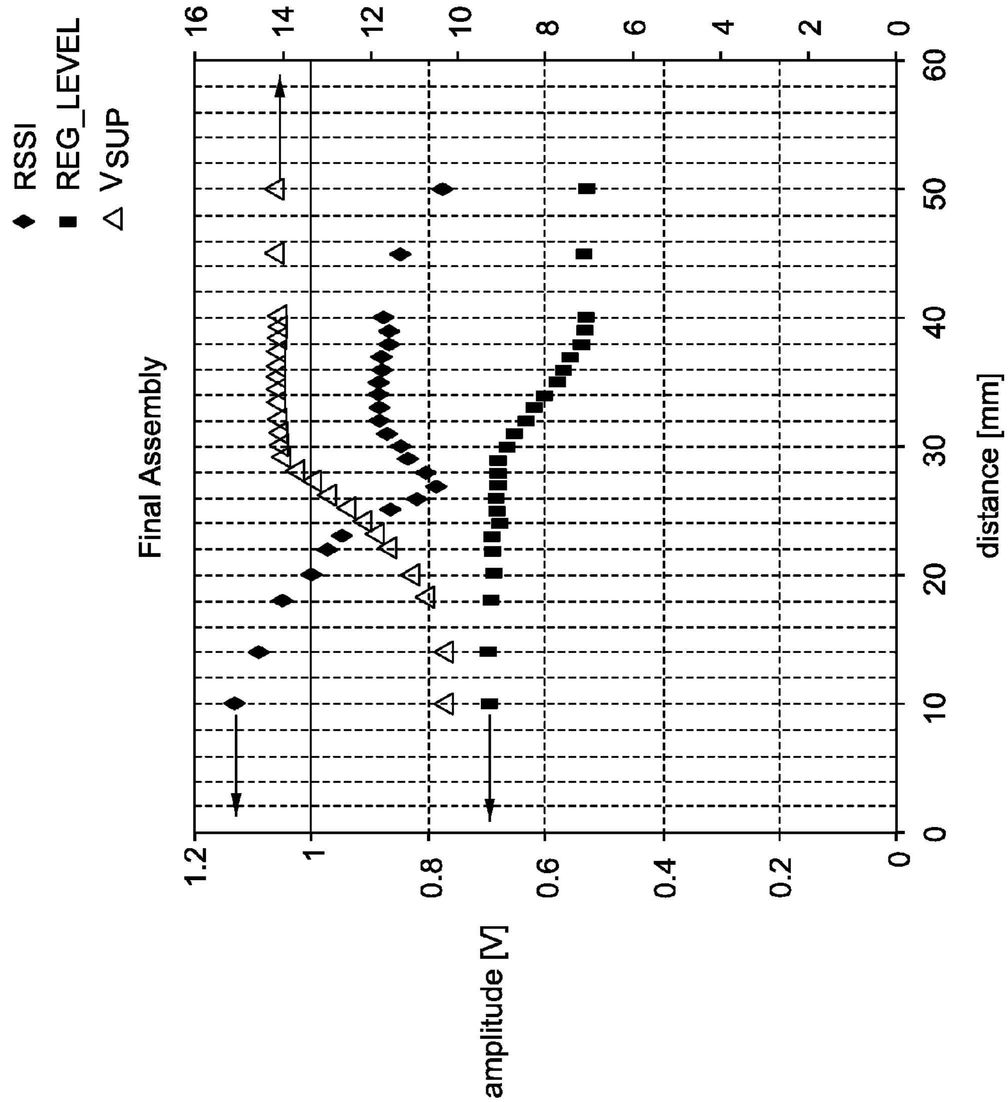

RSSI
RF_RX
VSUP_CTRL
2440
2446
2450
2422
2432
LPF
2420
2410
2444
REG_LEVEL
2442
RF_IN
FORCE_RF_PWR
ANT_RX
2400

FIG. 24



RSSI
REG_LEVEL
V_{SUP}
Final Assembly
amplitude [V]
distance [mm]
1.2
1
0.8
0.6
0.4
0.2
0
16
14
12
10
8
6
4
2
0
10
20
30
40
50
60

FIG. 25

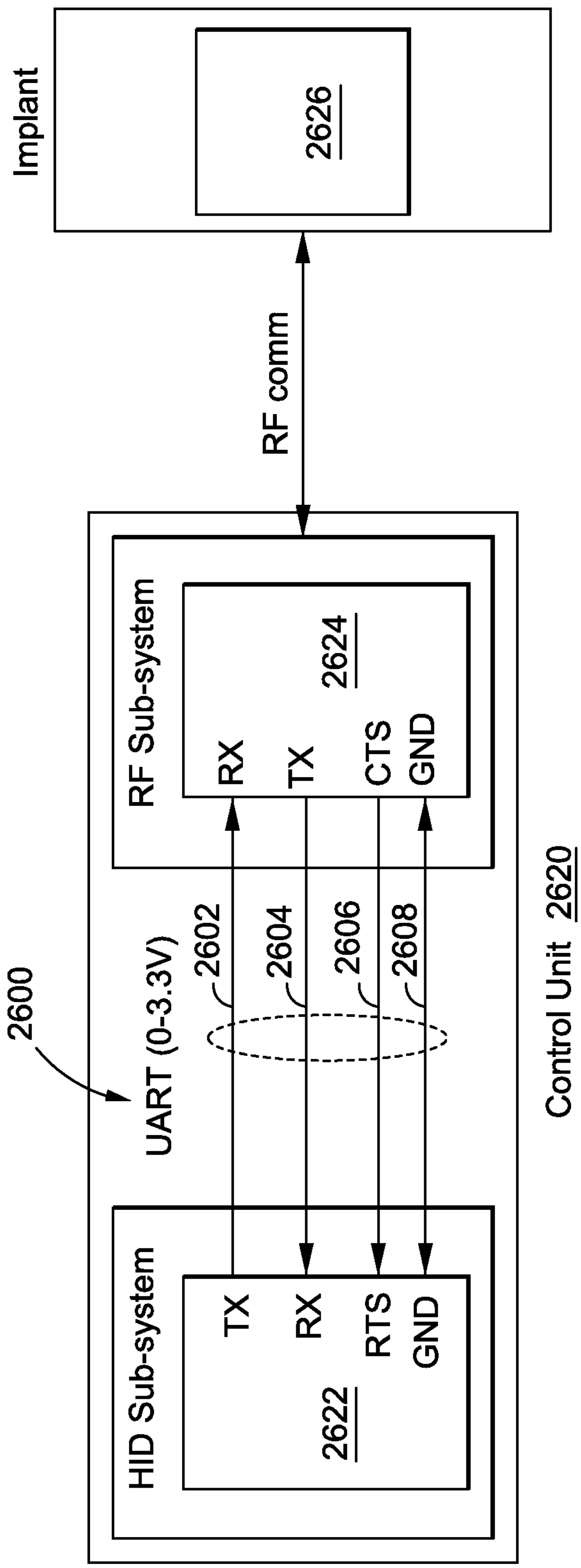

Implant
2626
RF comm
RF Sub-system
2624
RX
TX
CTS
GND
2600
UART (0-3.3V)
2602
2604
2606
2608
Control Unit 2620
HID Sub-system
TX
RX
RTS
GND
2622

FIG. 26

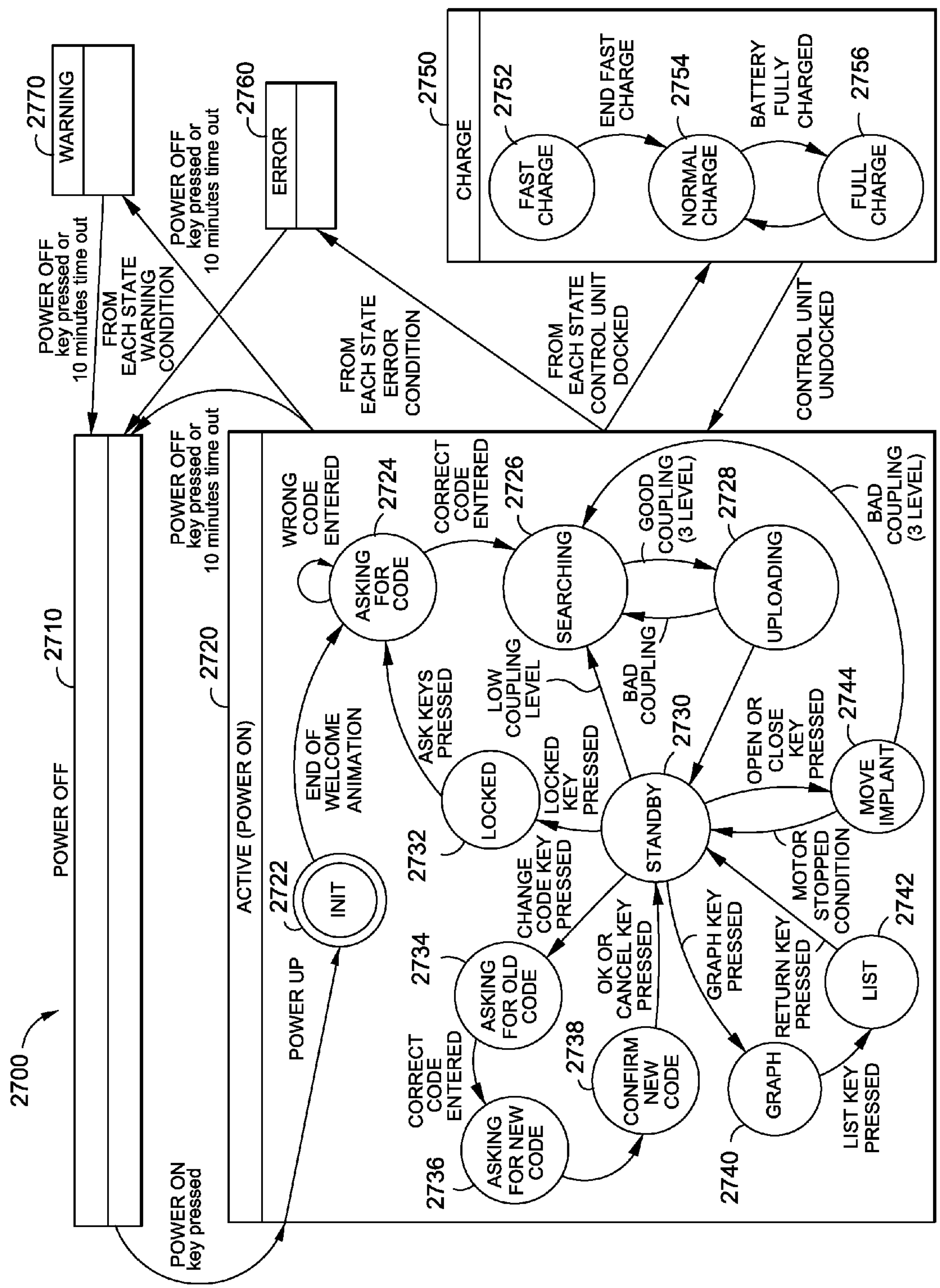

2700
POWER OFF
2710
WARNING
2770
ERROR
2760
CHARGE
2750
FAST CHARGE
2752
END FAST CHARGE
NORMAL CHARGE
2754
BATTERY FULLY CHARGED
FULL CHARGE
2756
POWER OFF key pressed or 10 minutes time out
FROM EACH STATE WARNING CONDITION
FROM EACH STATE ERROR CONDITION
FROM EACH STATE CONTROL UNIT DOCKED
CONTROL UNIT UNDOCKED
ACTIVE (POWER ON)
2720
POWER ON key pressed
POWER UP
INIT
2722
END OF WELCOME ANIMATION
ASKING FOR CODE
2724
WRONG CODE ENTERED
CORRECT CODE ENTERED
SEARCHING
2726
GOOD COUPLING (3 LEVEL)
UPLOADING
2728
BAD COUPLING (3 LEVEL)
BAD COUPLING
LOW COUPLING LEVEL
ASK KEYS PRESSED
LOCKED
2732
LOCKED KEY PRESSED
STANDBY
2730
OPEN OR CLOSE KEY PRESSED
MOVE IMPLANT
2744
MOTOR STOPPED CONDITION
CHANGE CODE KEY PRESSED
ASKING FOR OLD CODE
2734
CORRECT CODE ENTERED
ASKING FOR NEW CODE
2736
CONFIRM NEW CODE
2738
OK OR CANCEL KEY PRESSED
GRAPH KEY PRESSED
GRAPH
2740
LIST KEY PRESSED
LIST
2742
RETURN KEY PRESSED

FIG. 27

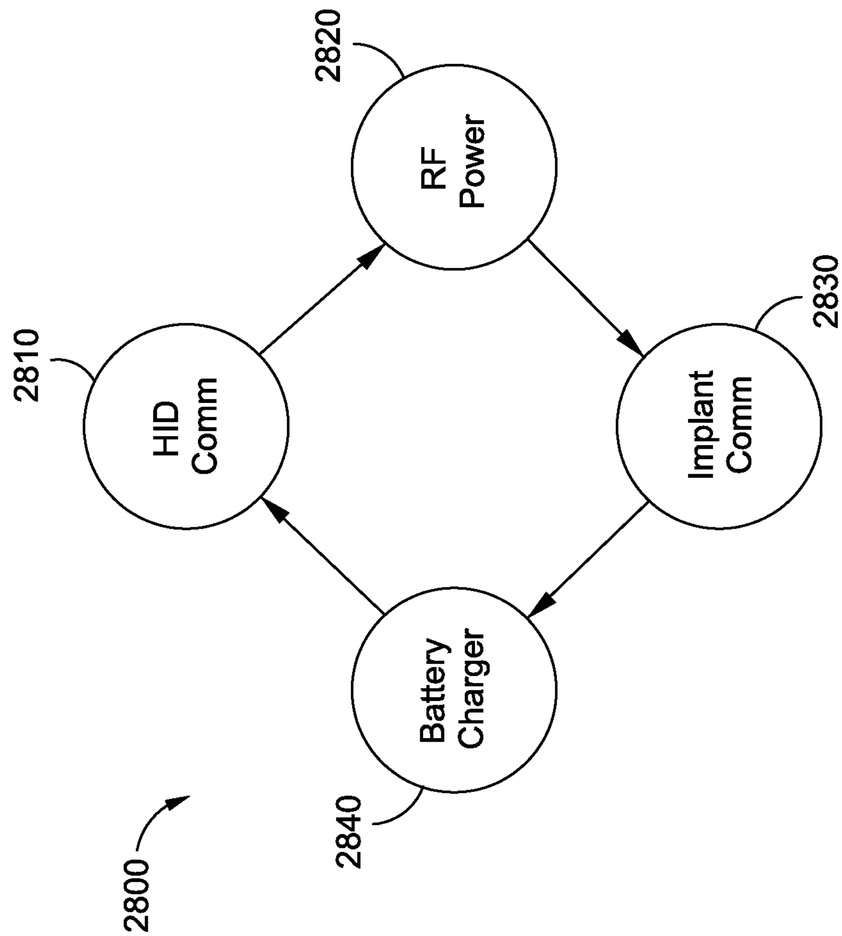

2800
2810
HID Comm
2820
RF Power
2830
Implant Comm
2840
Battery Charger

FIG. 28

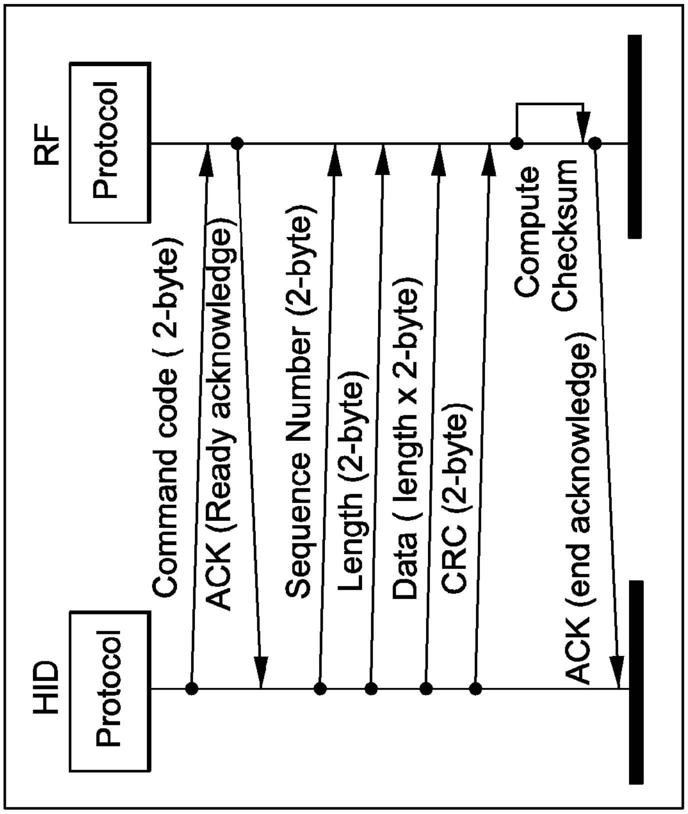


FIG. 29B

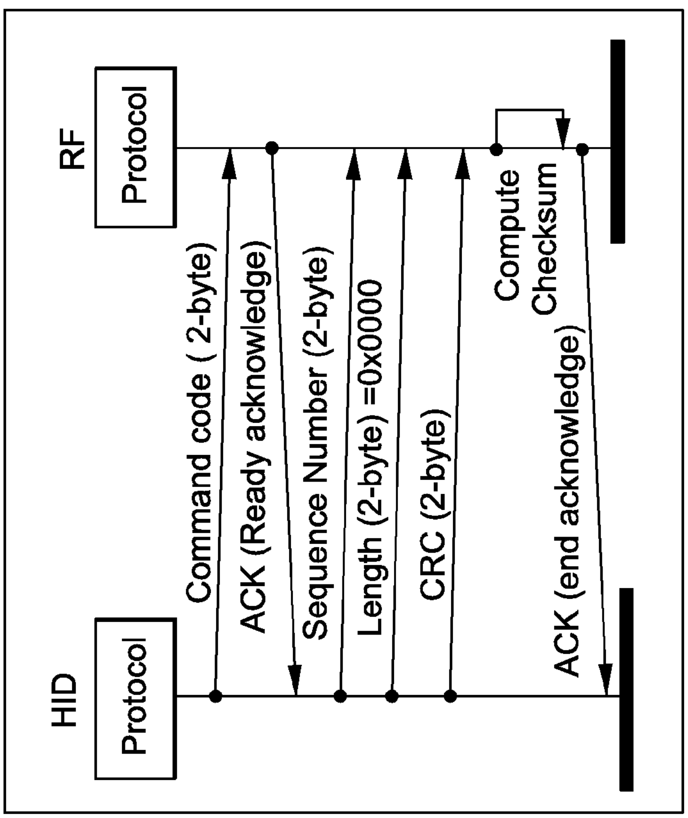


FIG. 29A

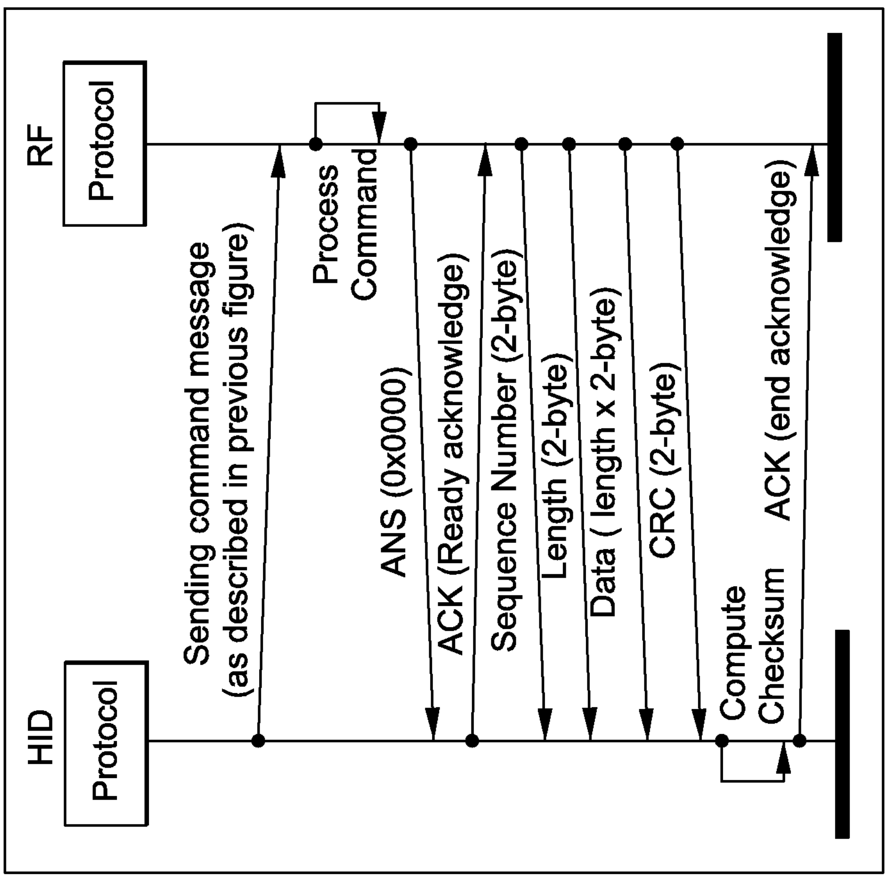

RF
Protocol
HID
Protocol
Sending command message
(as described in previous figure)
Process
Command
ANS (0x0000)
ACK (Ready acknowledge)
Sequence Number (2-byte)
Length (2-byte)
Data (length x 2-byte)
CRC (2-byte)
Compute
Checksum
ACK (end acknowledge)

FIG. 30

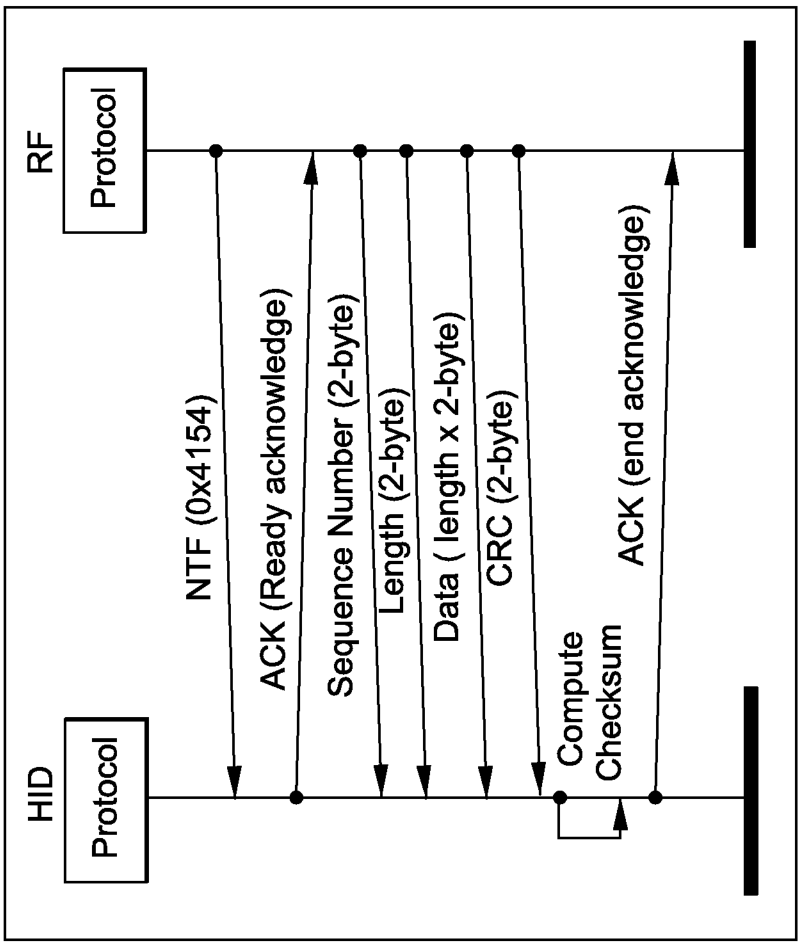

RF
Protocol
HID
Protocol
NTF (0x4154)
ACK (Ready acknowledge)
Sequence Number (2-byte)
Length (2-byte)
Data (length x 2-byte)
CRC (2-byte)
Compute
Checksum
ACK (end acknowledge)

FIG. 31

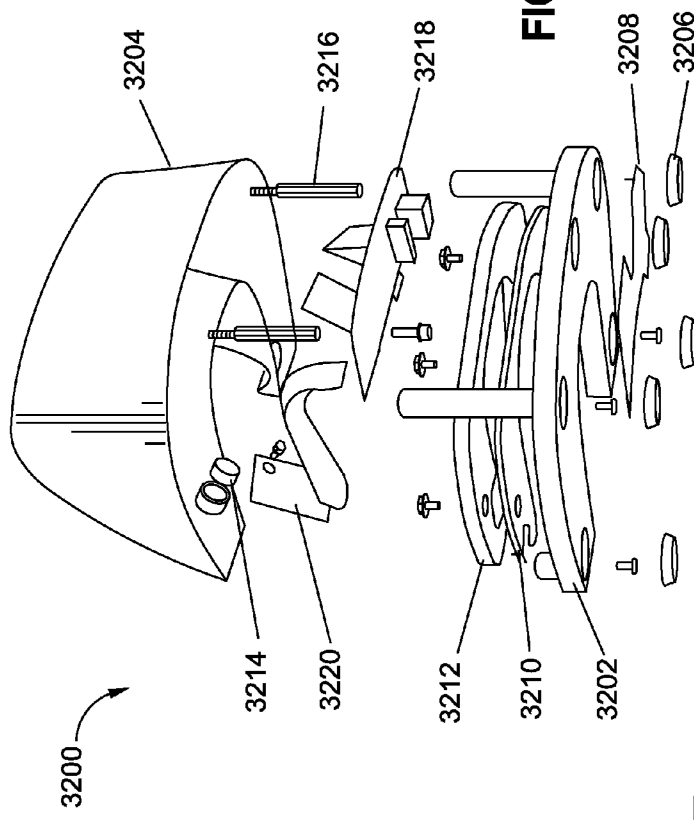


FIG. 32A

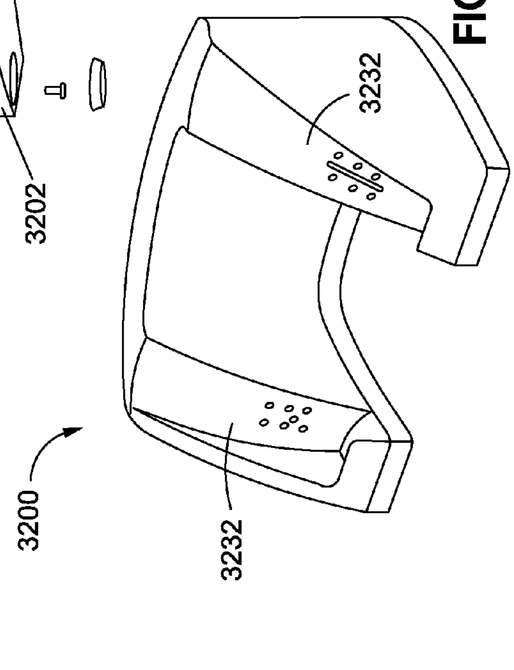


FIG. 32B

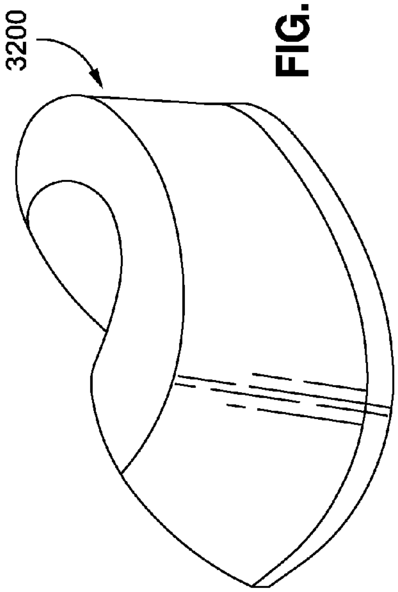


FIG. 32C

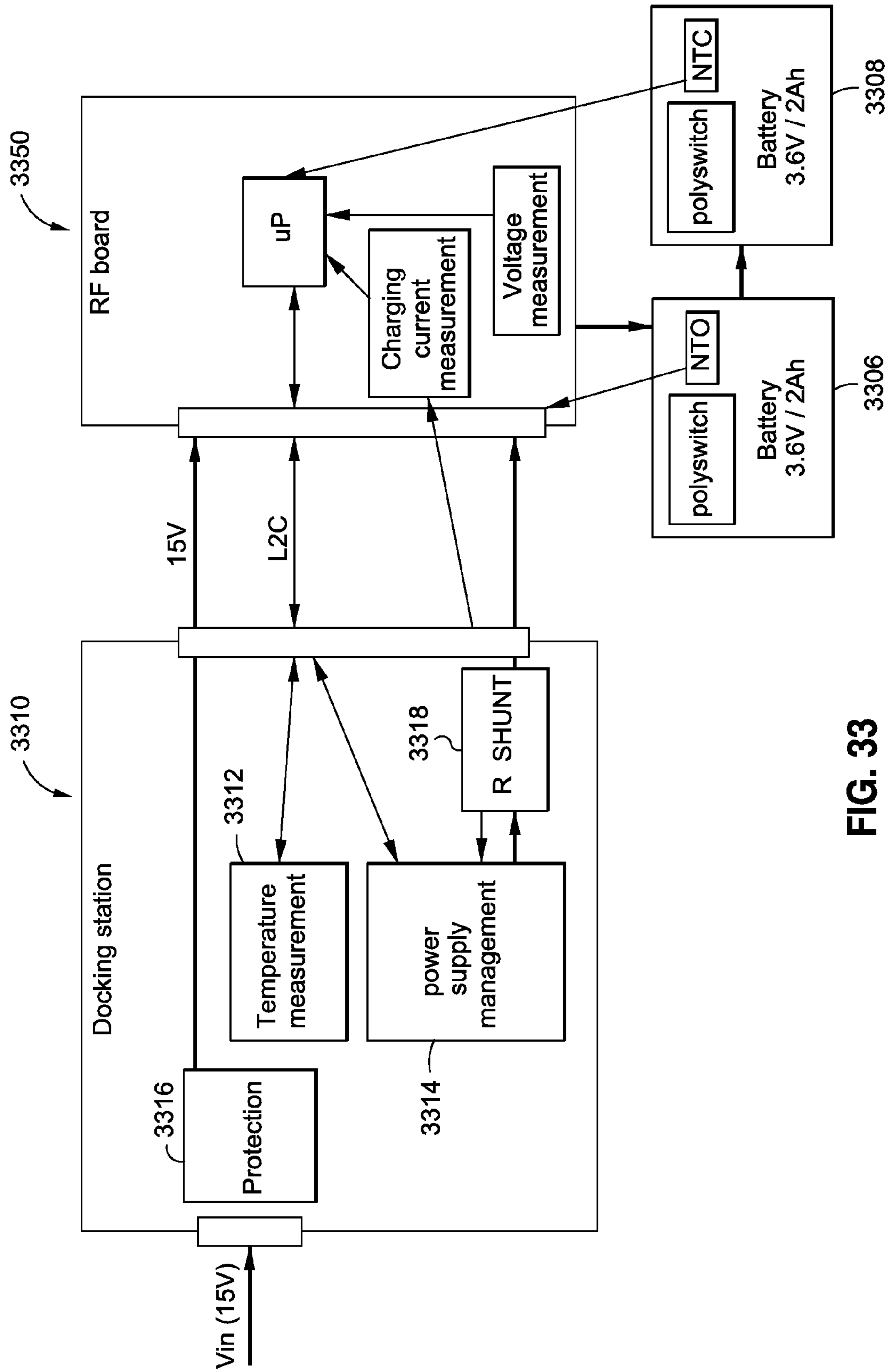

3350
RF board
uP
Charging current measurement
Voltage measurement
NTC
polyswitch
Battery 3.6V / 2Ah
3308
NTO
polyswitch
Battery 3.6V / 2Ah
3306
15V
L2C
3310
Docking station
3312
Temperature measurement
3318
R SHUNT
power supply management
3314
3316
Protection
Vin (15V)

FIG. 33

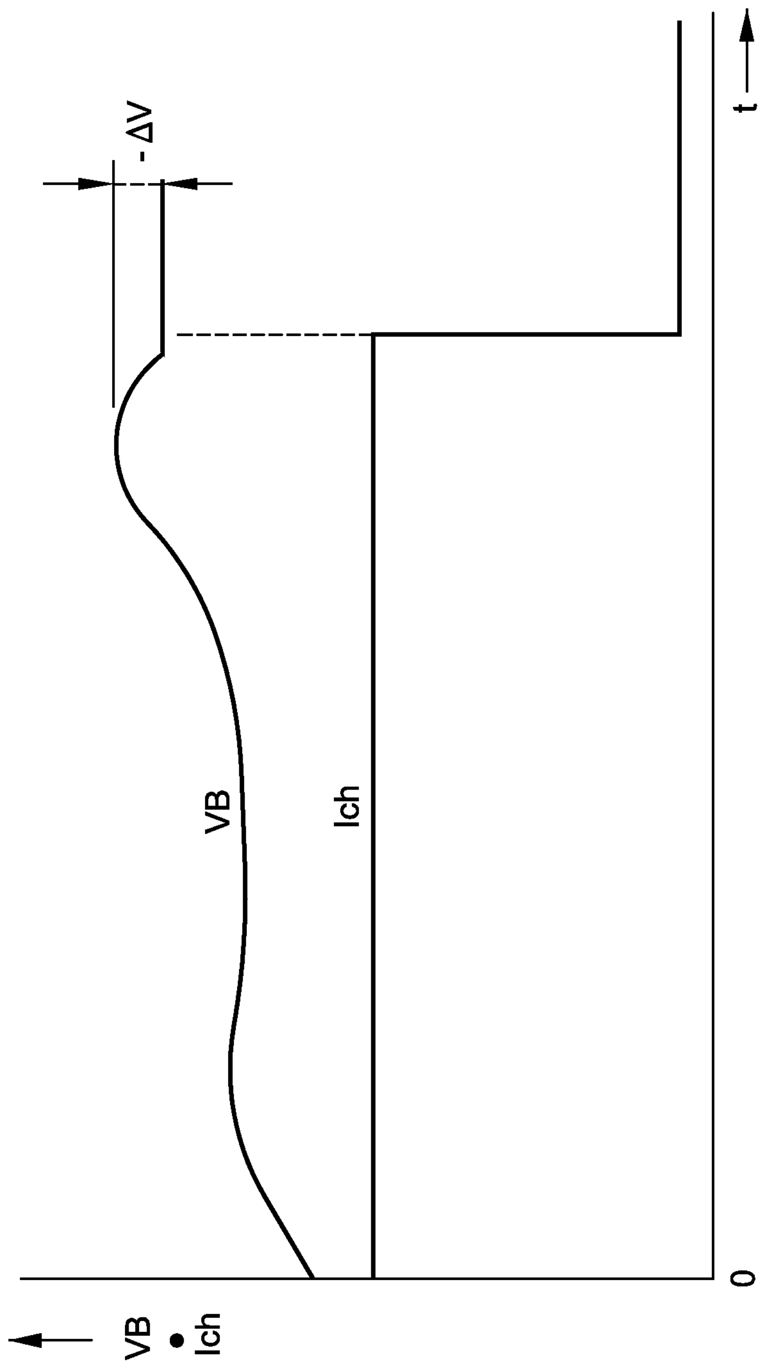


FIG. 34

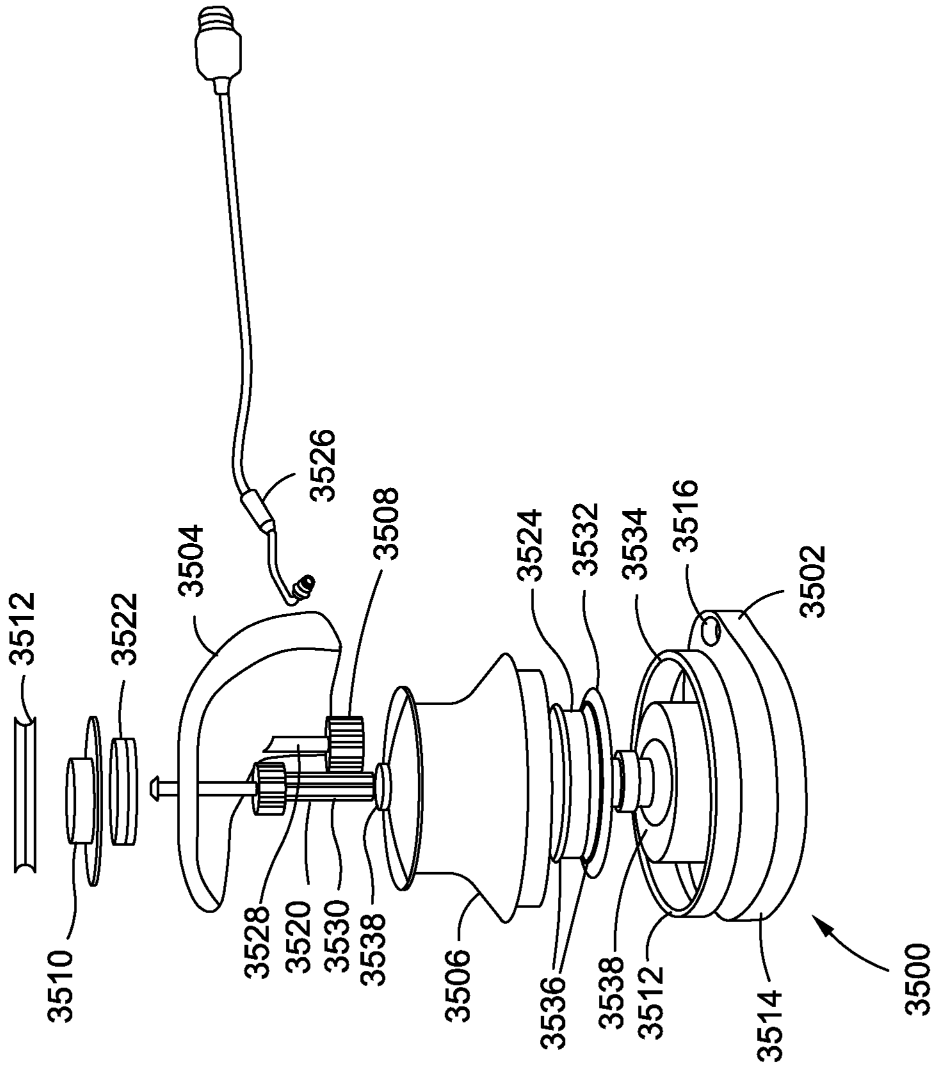


FIG. 35B

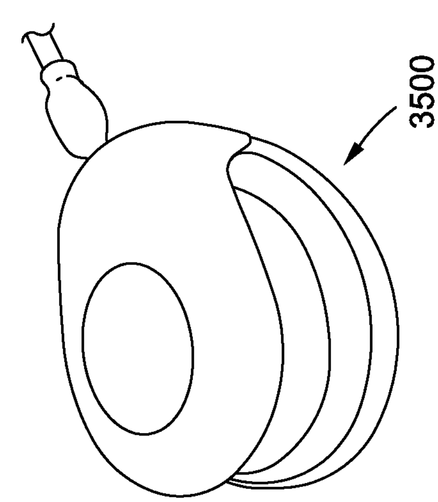


FIG. 35A

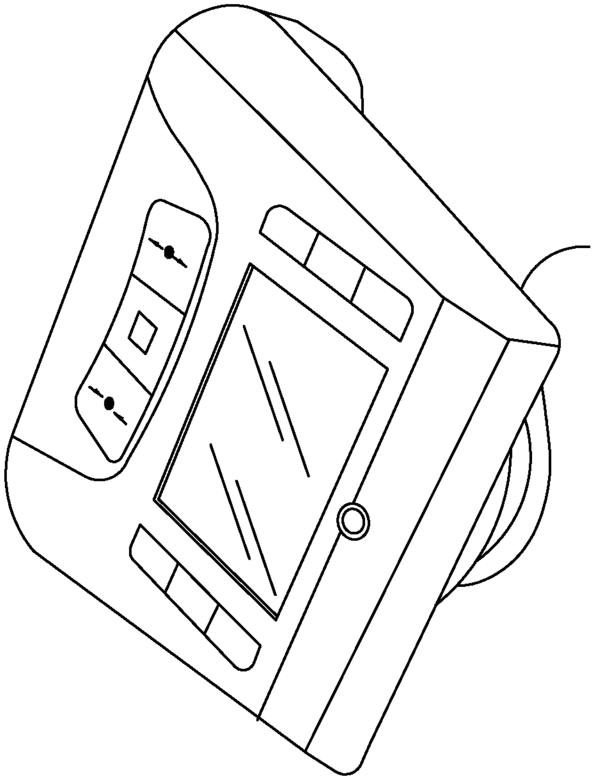


FIG. 36B

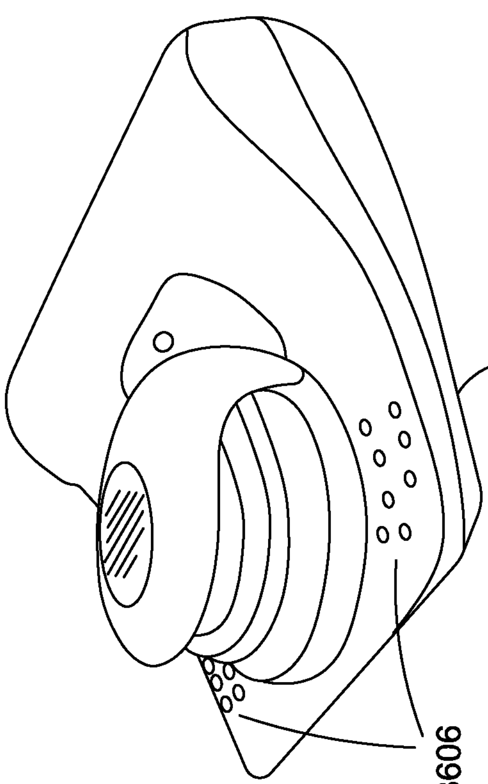


FIG. 36A

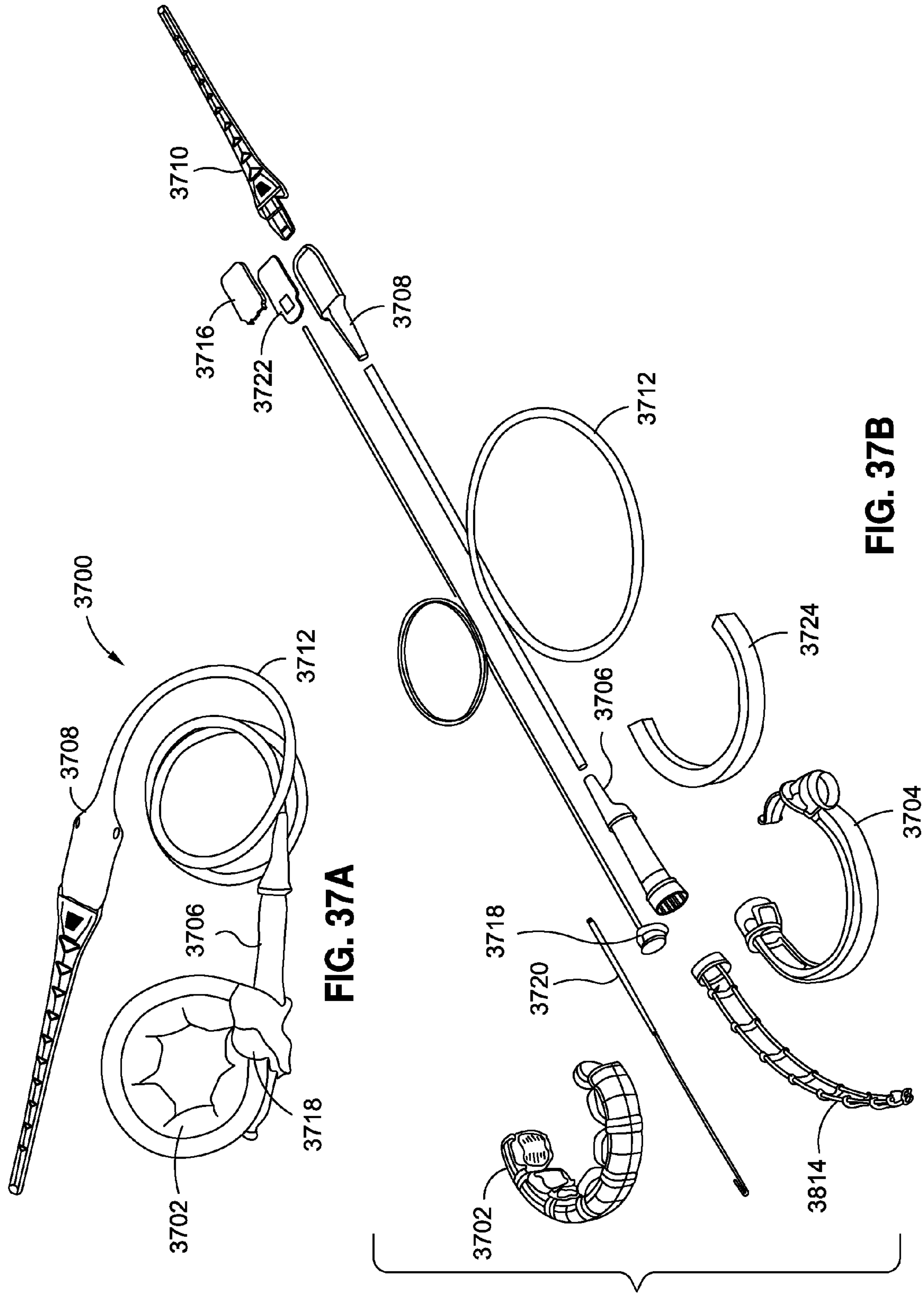


FIG. 37A

FIG. 37B

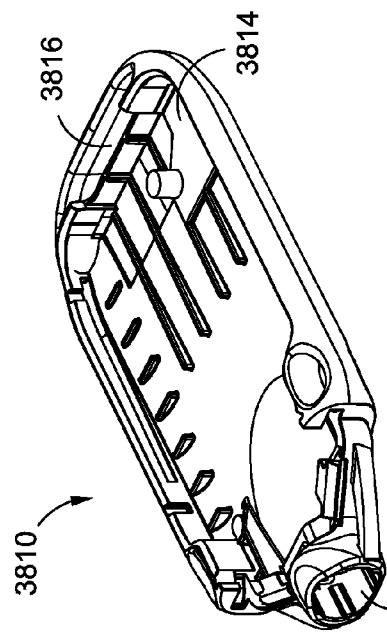


FIG. 38A

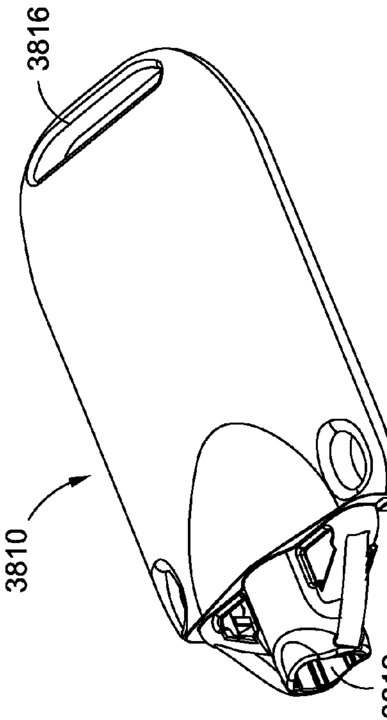


FIG. 38B

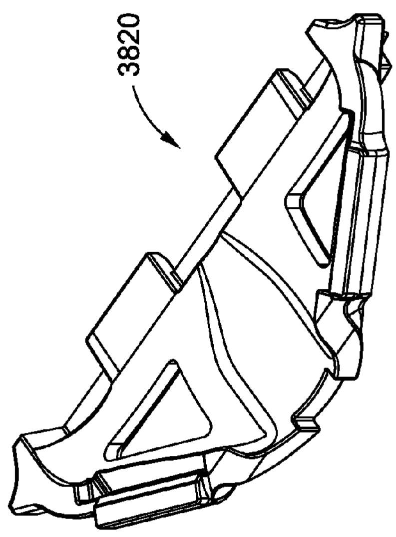


FIG. 38C

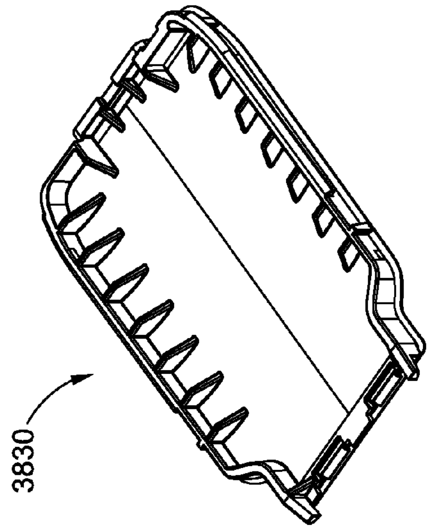


FIG. 38D

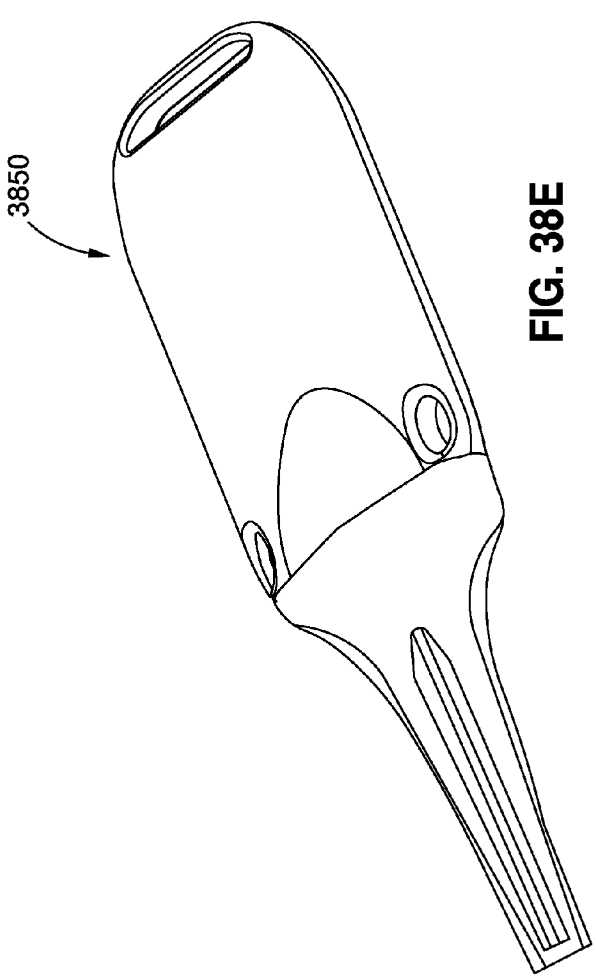


FIG. 38E

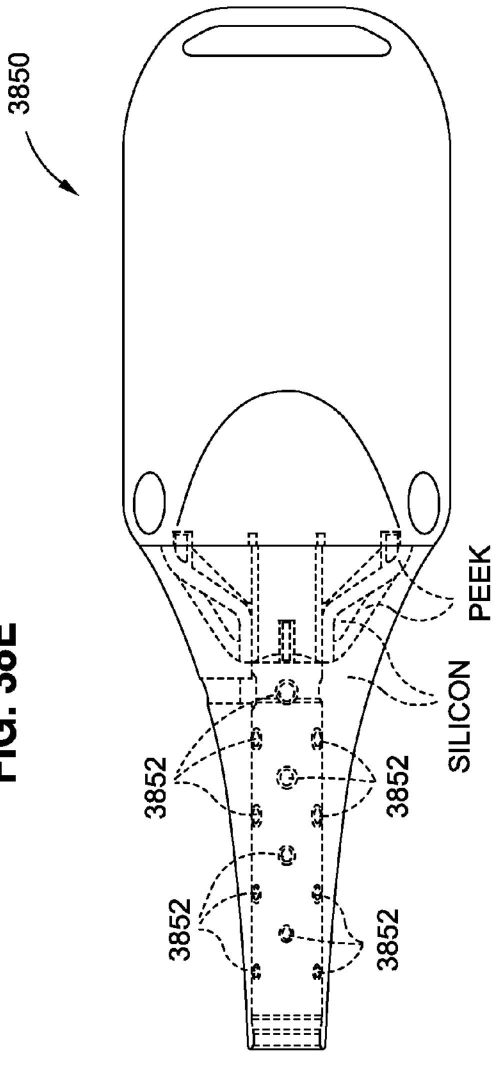


FIG. 38F

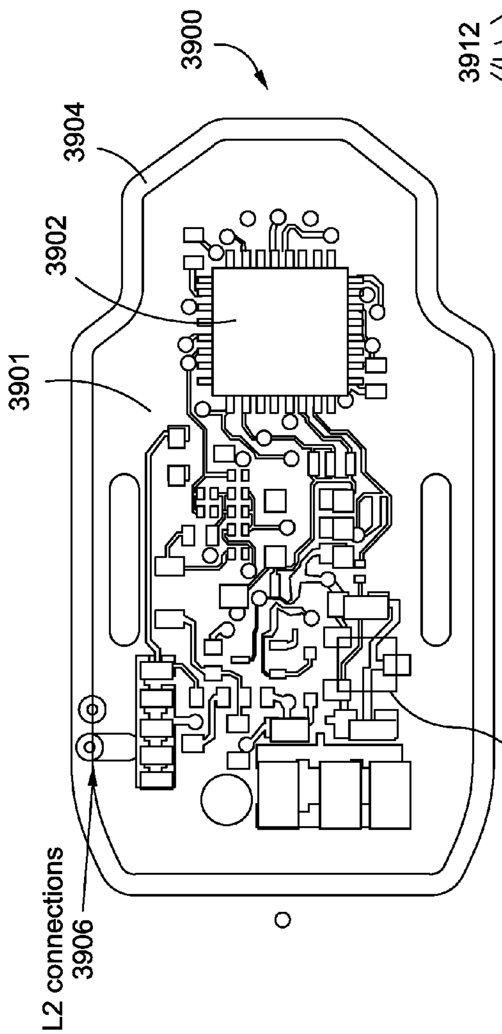


FIG. 39A

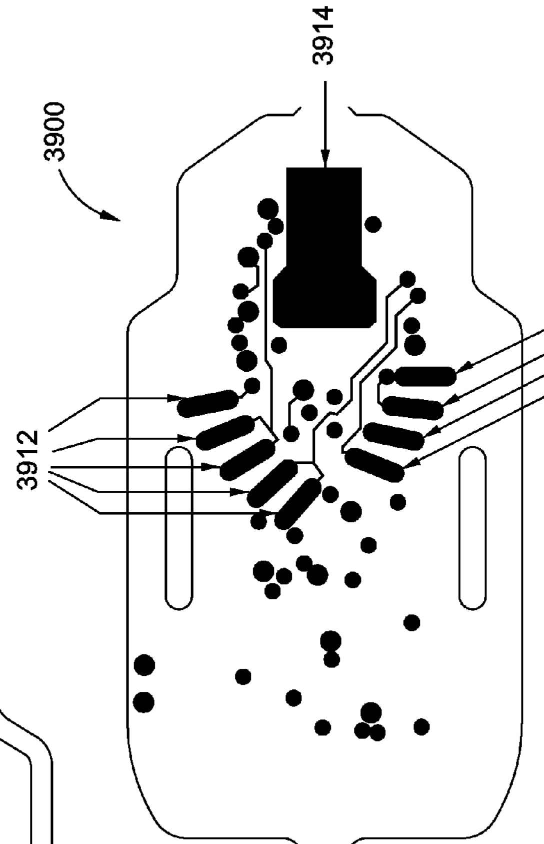


FIG. 39B

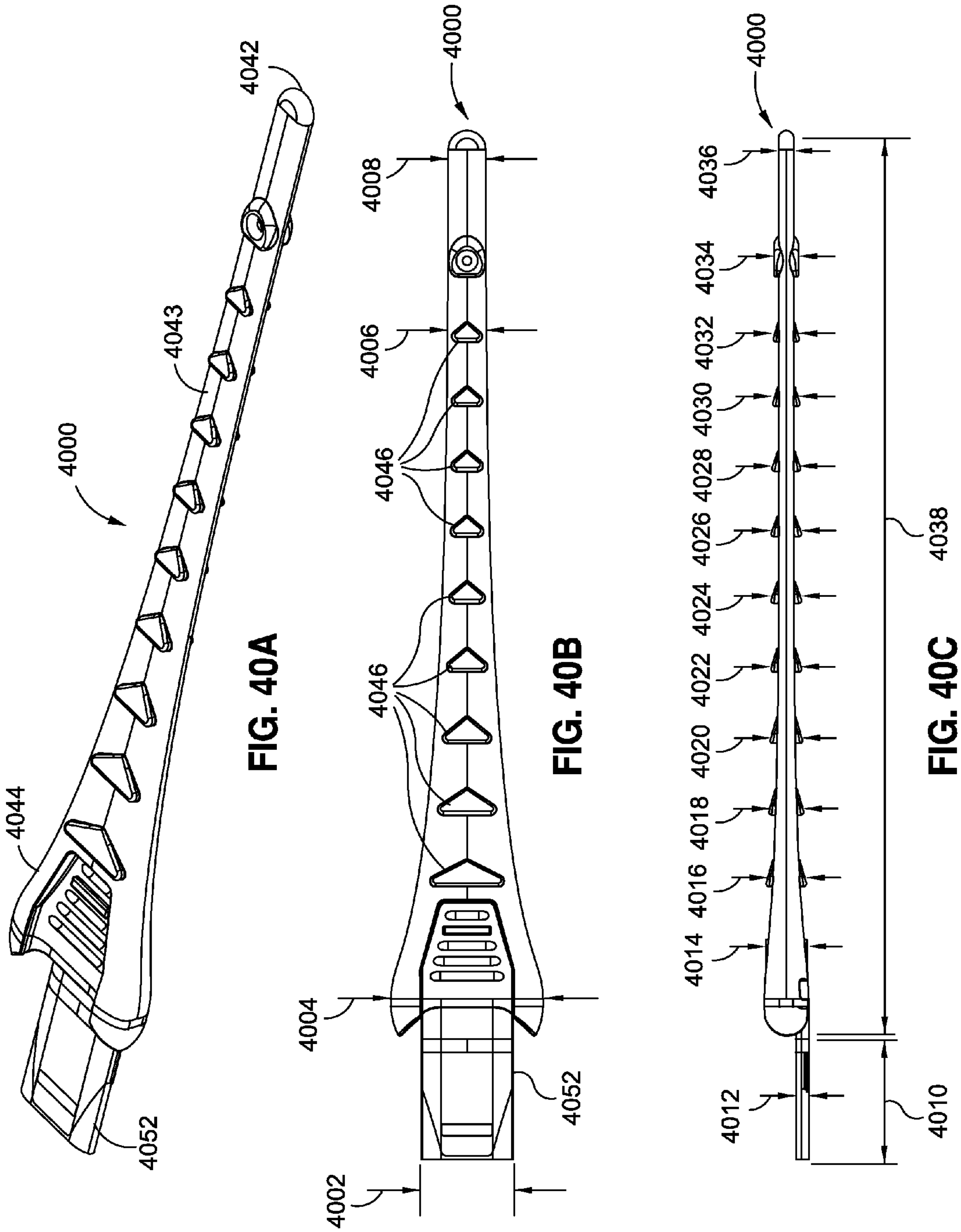
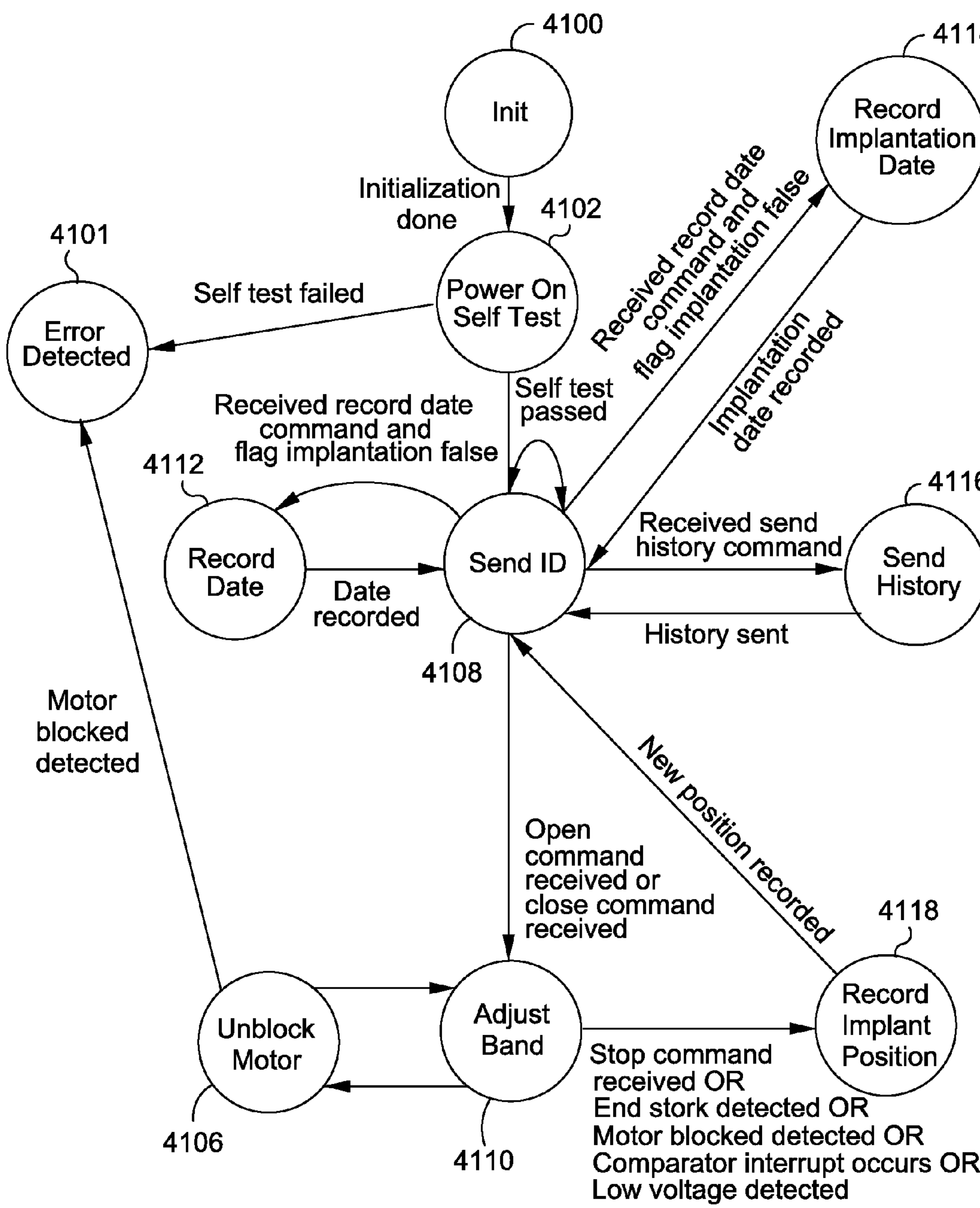


FIG. 40A

FIG. 40B

FIG. 40C



4100
Init
Initialization done
4102
Power On Self Test
4101
Error Detected
Self test failed
Self test passed
4114
Record Implantation Date
Received record date command and flag implantation false
Implantation date recorded
Received record date command and flag implantation false
4112
Record Date
Date recorded
Send ID
4108
4116
Received send history command
Send History
History sent
Motor blocked detected
New position recorded
Open command received or close command received
4118
Record Implant Position
Unblock Motor
Adjust Band
4106
4110
Stop command received OR
End stork detected OR
Motor blocked detected OR
Comparator interrupt occurs OR
Low voltage detected

FIG. 41

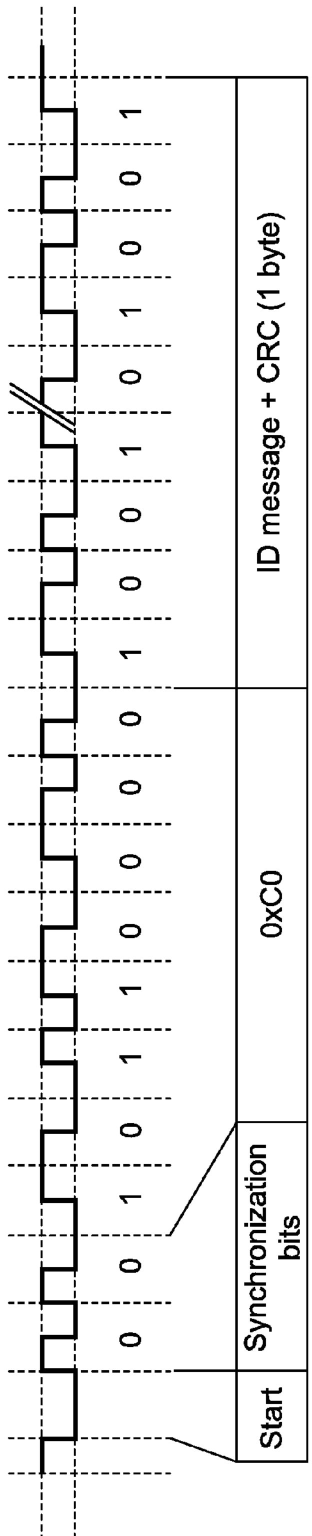


FIG. 42A

Answer Message	
Data	Data[0]: 0xC0 (1-byte)
	Data[1]: 1D2 (1-byte)
	Data[2]: 1D1 (1-byte)
	Data[3]: 1D0 (1-byte)
	Data[4]: Status1 (1-byte)
	Data[5]: Status0 (1-byte)
	Data[6]: Position2 (1-byte)
	Data[7]: Position1 (1-byte)
	Data[8]: Position0 (1-byte)
	Data[9]: CRC (1-byte)

FIG. 42B

FIG. 43A

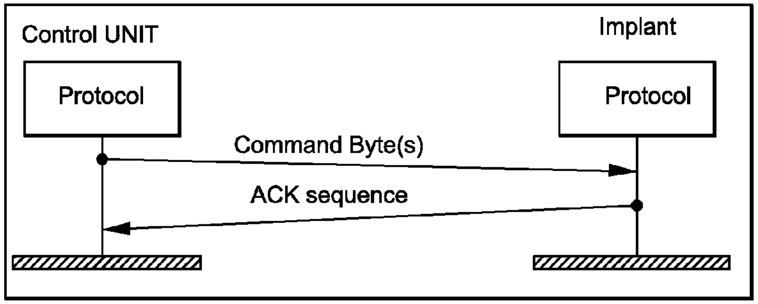
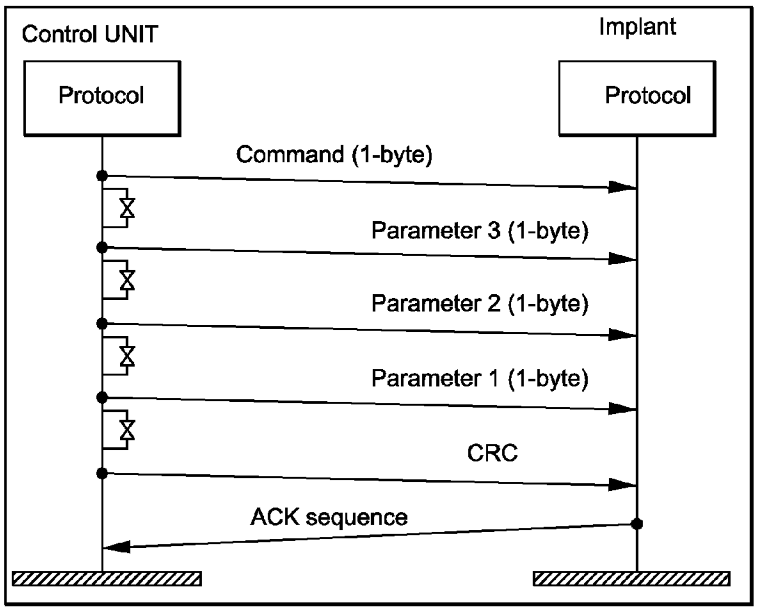


FIG. 43B

BINARY CODE								
B7	B5	B5	B4	B3	B2	B1	B0	CMD Name
1	0	0	0	1	0	1	1	ImplantRequestStopPower
1	0	0	1	0	0	0	1	ImplantRequestSelfTest
1	0	0	1	0	0	1	0	ImplanGetCurrentDate
1	0	0	1	0	1	1	1	ImplantGetSerialNumber
1	0	0	1	1	1	1	0	ImplantGetFirmwareVersion
1	0	0	1	1	0	0	0	ImplantGetStopCounter
1	0	1	0	0	0	1	1	ImplantEepromRecovery
1	0	0	0	1	1	0	0	ImplantGetExtendedStatusRegister



4408

FIG. 44A

BINARY CODE								
B7	B5	B5	B4	B3	B2	B1	B0	CMD Name
0	1	0	0	0	0	0	1	ImplantOpenNStep
0	1	0	0	0	0	1	0	ImplantCloseNStep
0	1	0	0	0	1	1	0	ImplanWriteByteEeprom
1	1	0	0	1	1	1	0	ImplantSetCurrentDate
1	1	0	0	1	1	1	1	ImplantReadHistory
1	1	1	0	1	0	1	1	ImplantGetParameters
1	1	1	0	0	0	1	1	ImplantReadEepromMemory

FIG. 44B

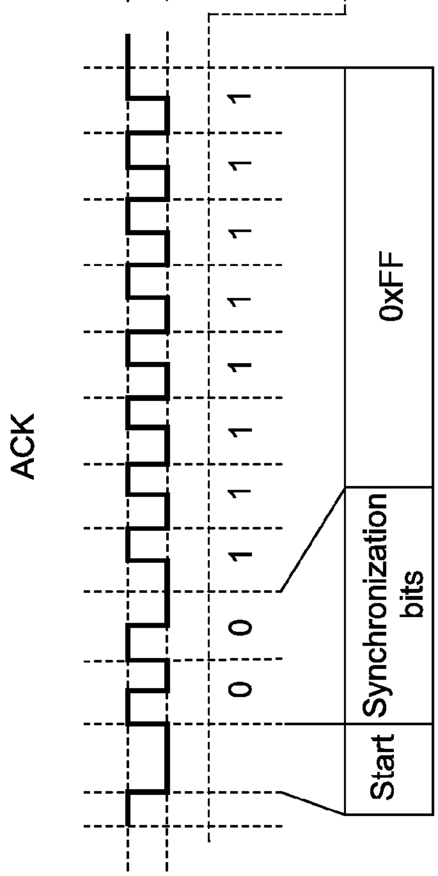


FIG. 45A

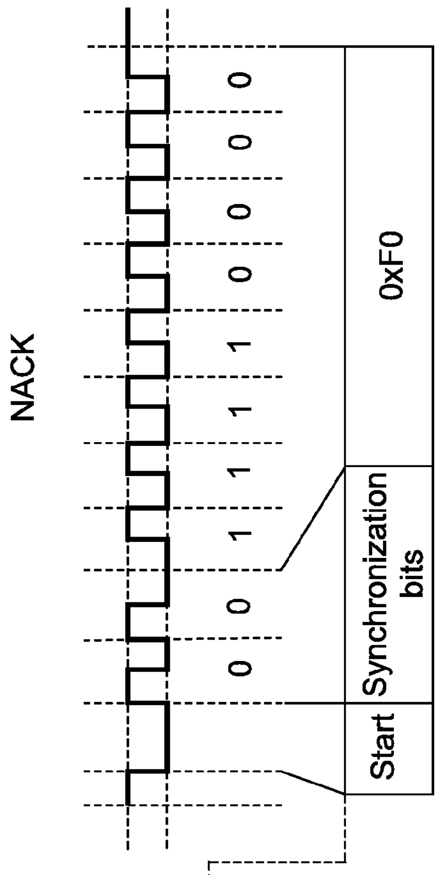


FIG. 45B

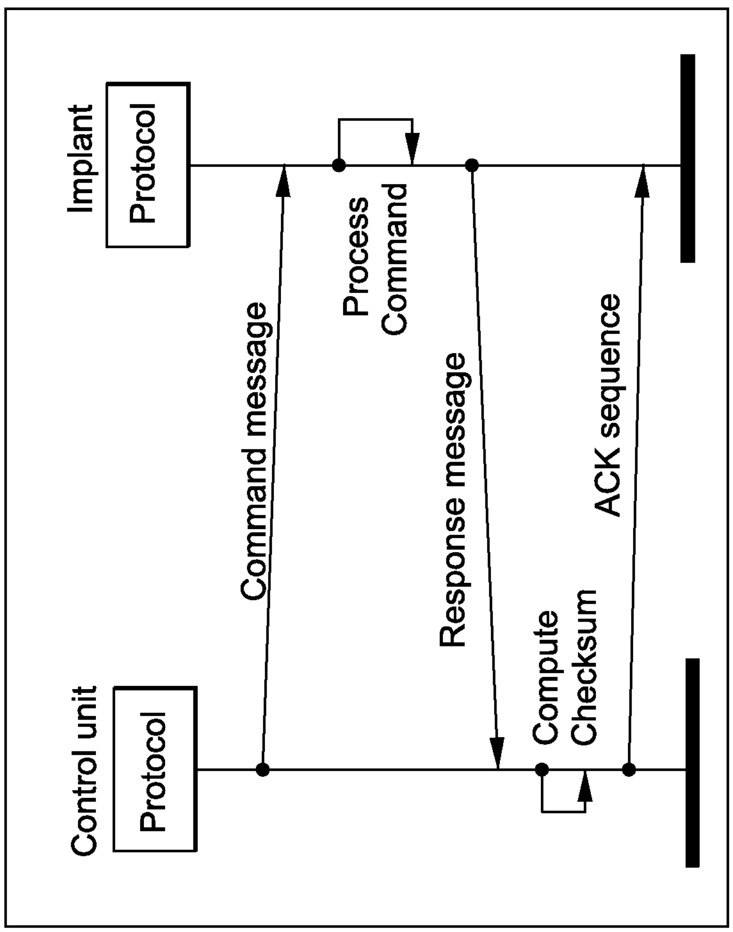

Control unit
Protocol
Implant
Protocol
Command message
Process
Command
Response message
Compute
Checksum
ACK sequence

FIG. 46A

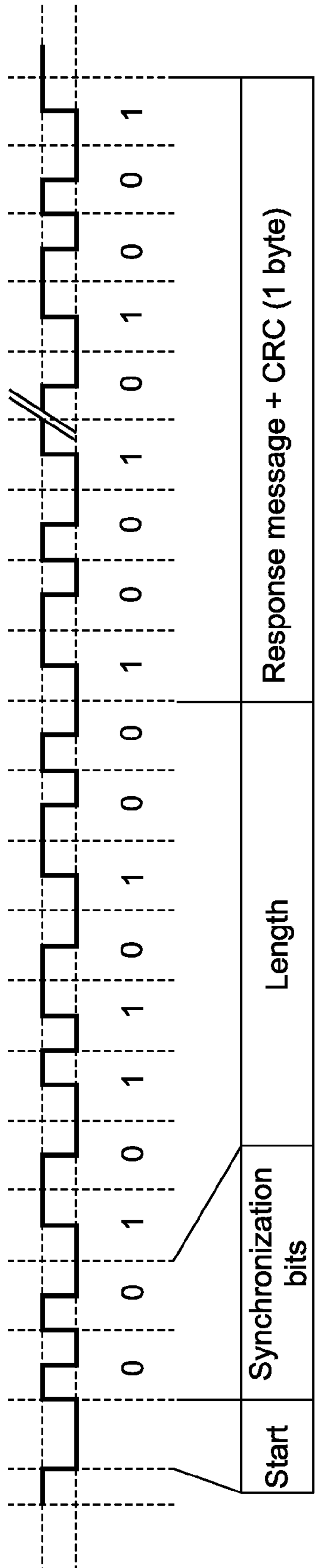

Start
Synchronization bits
Length
Response message + CRC (1 byte)

FIG. 46B

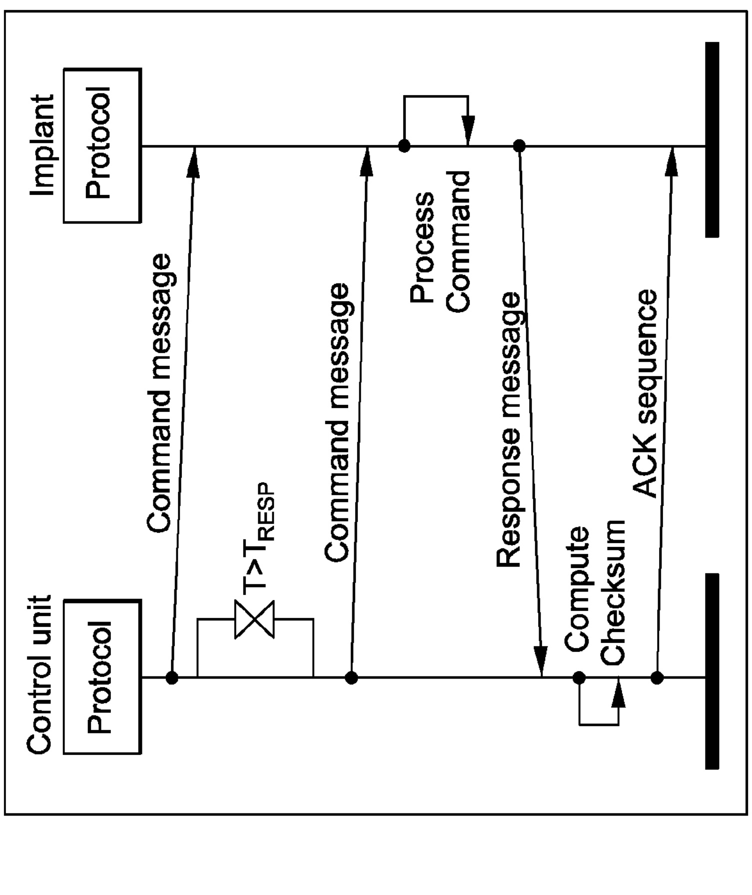


FIG. 47A

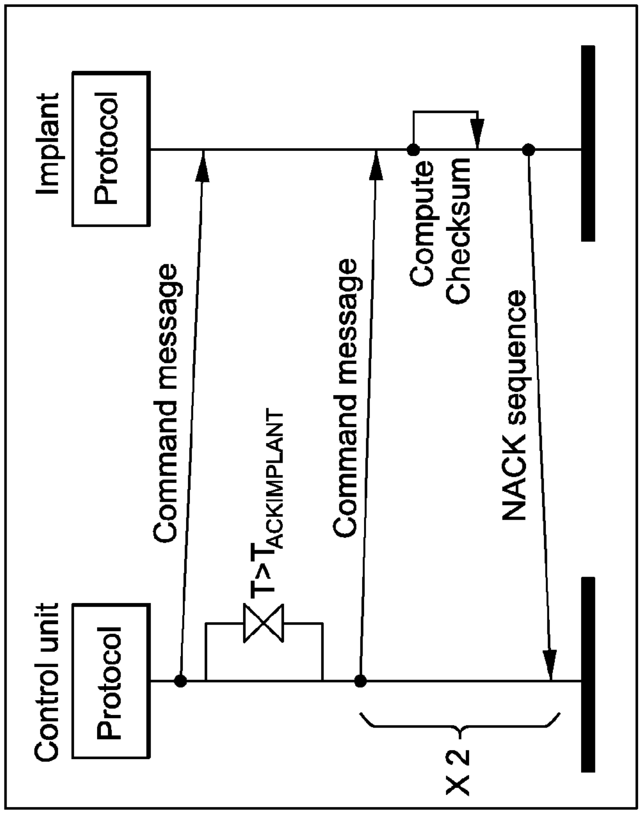


FIG. 47B

4800

Band's position				Date			CRC
Byte3	Byte2	Byte1	Byte0	Byte2	Byte1	Byte0	Byte0

FIG. 48

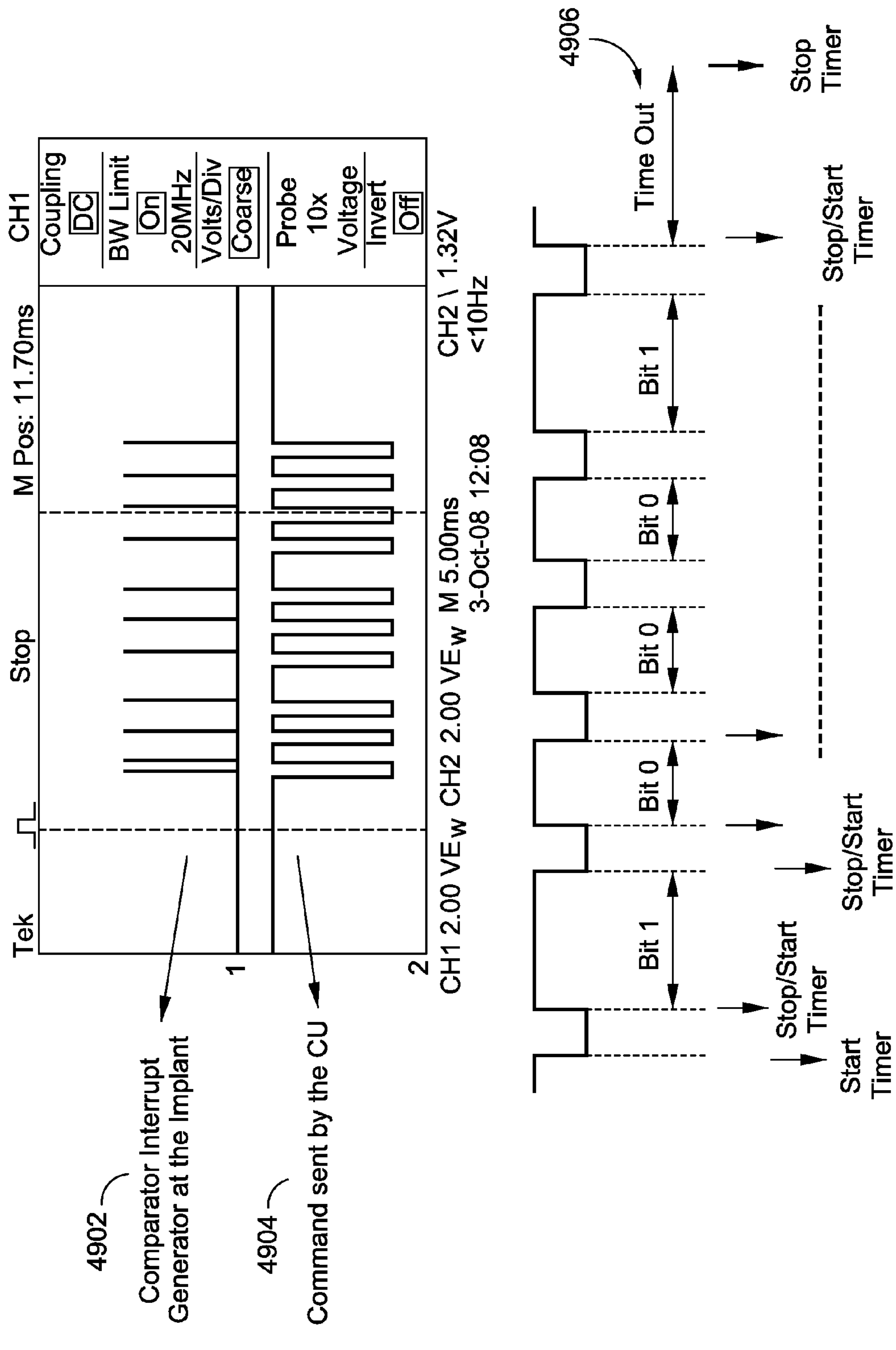
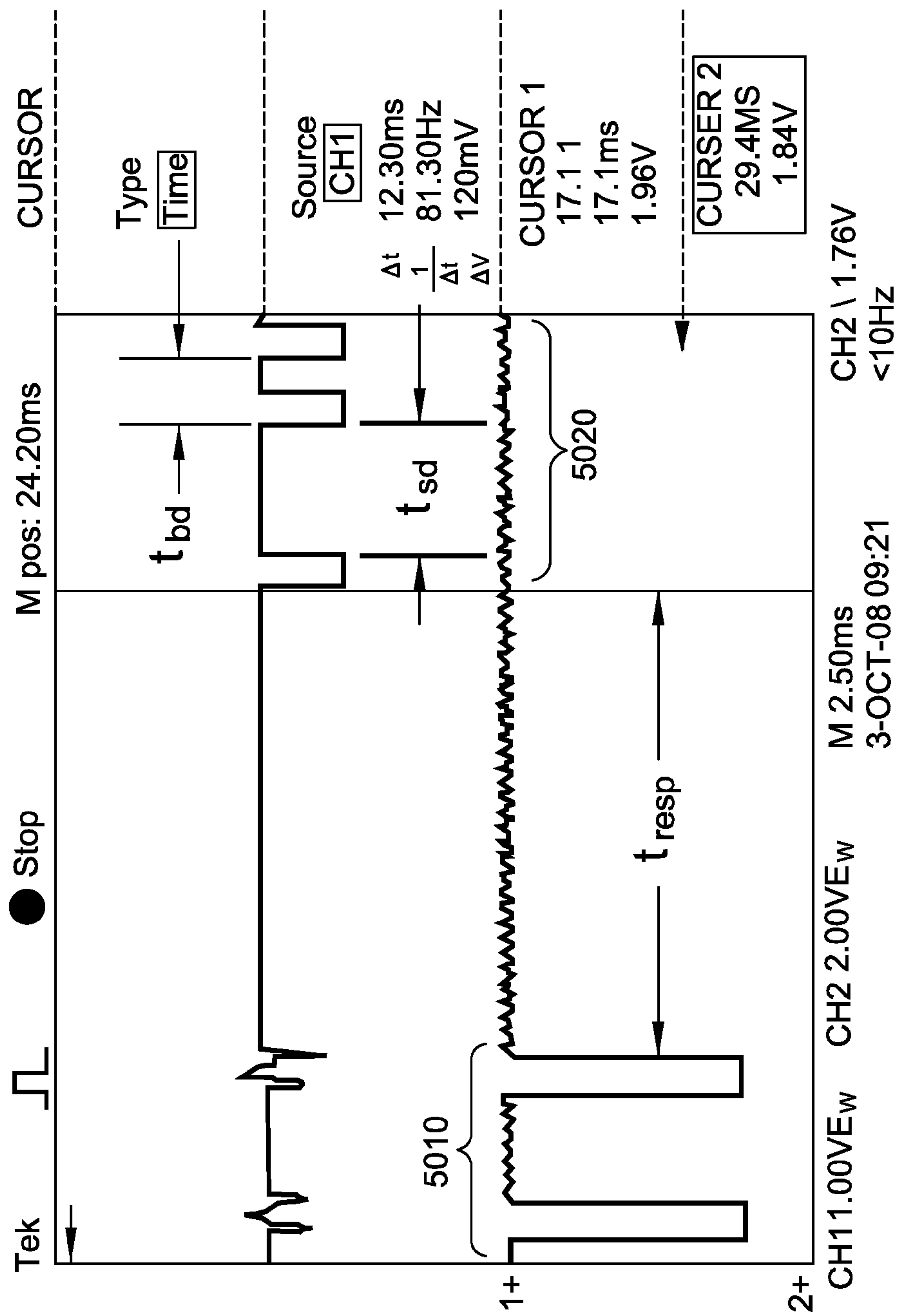

Tek
Stop
M Pos: 11.70ms
CH1
Coupling
DC
BW Limit
On
20MHz
Volts/Div
Coarse
Probe
10x
Voltage
Invert
Off
1
2
CH1 2.00 VE_W CH2 2.00 VE_W M 5.00ms CH2 \ 1.32V
3-Oct-08 12:08 <10Hz
4902
Comparator Interrupt Generator at the Implant
4904
Command sent by the CU
4906
Time Out
Bit 1
Bit 0
Bit 0
Bit 0
Bit 1
Start Timer
Stop/Start Timer
Stop/Start Timer
Stop/Start Timer
Stop/Start Timer
Stop Timer

FIG. 49



Tek
Stop
M pos: 24.20ms
CURSOR
Type
Time
Source
CH1
Δt 12.30ms
1/Δt 81.30Hz
ΔV 120mV
CURSOR 1
17.1 1
17.1ms
1.96V
CURSER 2
29.4MS
1.84V
t_{bd}
t_{sd}
t_{resp}
5010
5020
1+
2+
CH1 1.00VE$_W$
CH2 2.00VE$_W$
M 2.50ms
3-OCT-08 09:21
CH2 \ 1.76V
<10Hz

FIG. 50

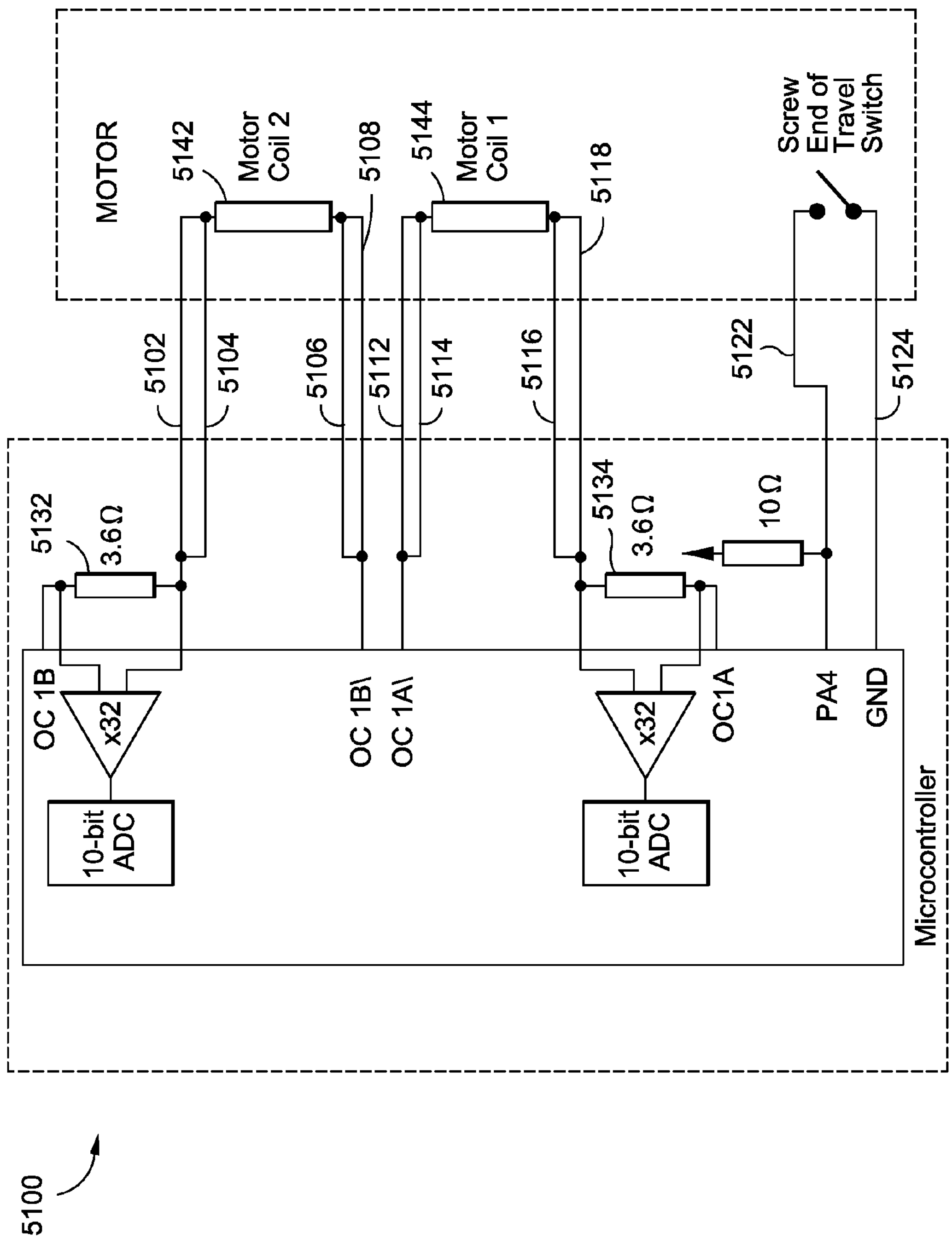

MOTOR
5142
Motor Coil 2
5108
5144
Motor Coil 1
5118
Screw End of Travel Switch
5102
5104
5106
5112
5114
5116
5122
5124
5132
3.6Ω
5134
3.6Ω
10Ω
OC 1B
x32
10-bit ADC
OC 1B\
OC 1A\
x32
OC1A
10-bit ADC
PA4
GND
Microcontroller
5100

FIG. 51

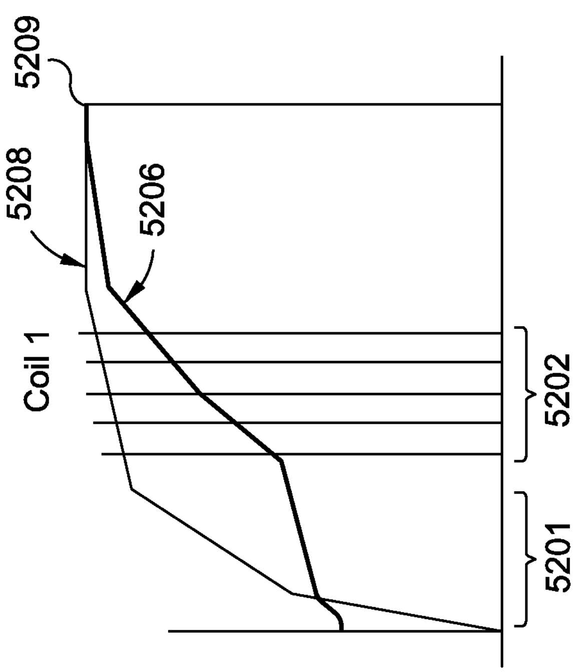


FIG. 52

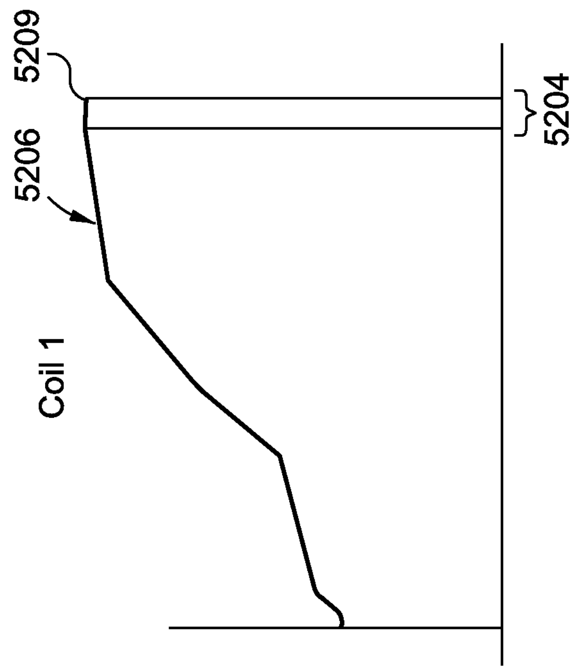


FIG. 53

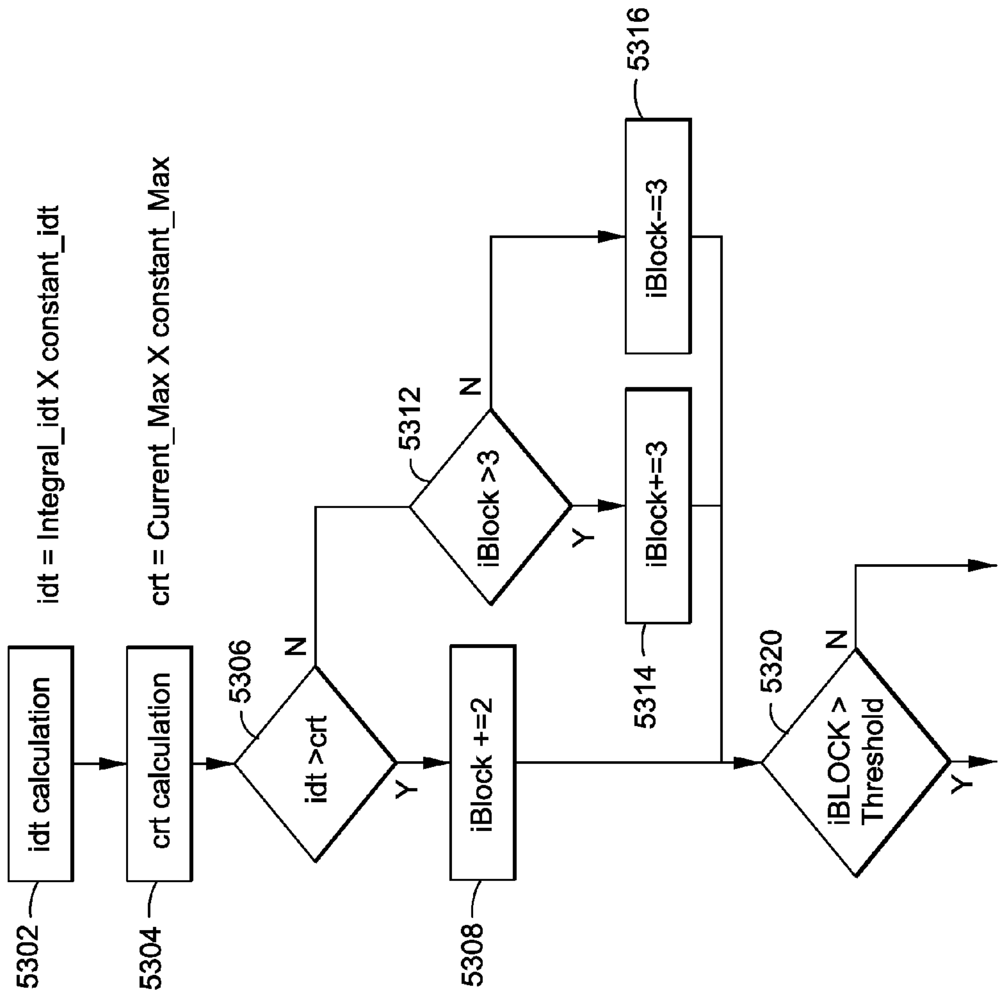

idt = Integral_idt X constant_idt
crt = Current_Max X constant_Max
idt calculation
5302
crt calculation
5304
idt >crt
5306
Y
N
iBlock +=2
5308
iBlock >3
5312
Y
N
iBlock+=3
5314
iBlock-=3
5316
iBLOCK > Threshold
5320
Y
N
change sequence
Continue with same sequence

FIG. 54

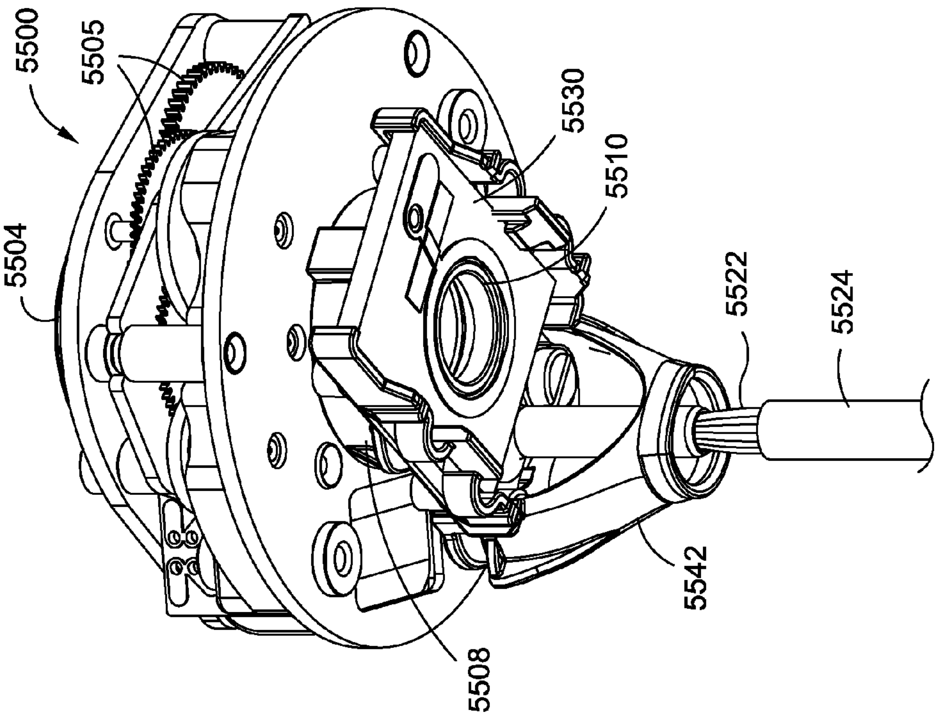


FIG. 55B

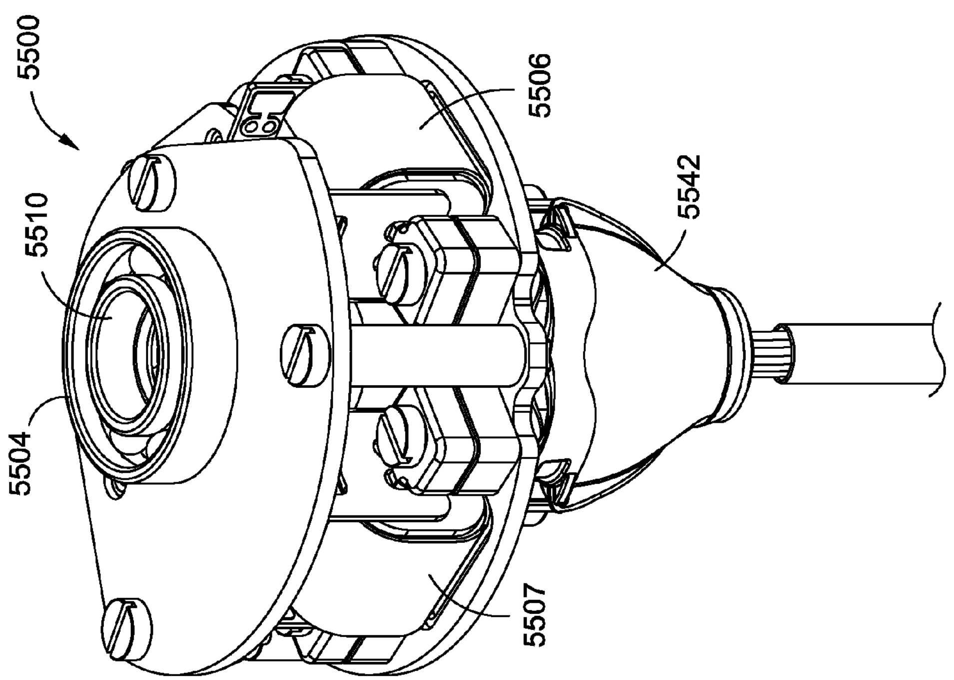


FIG. 55A

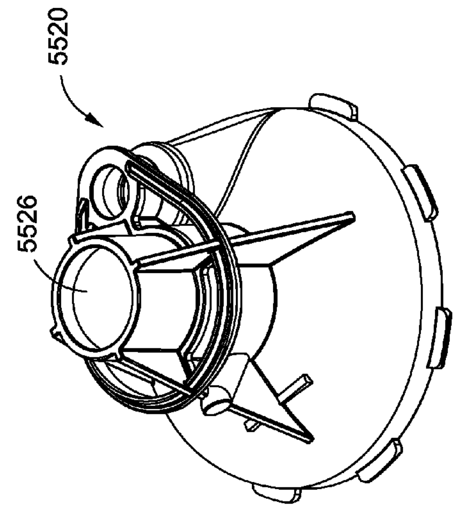


FIG. 55D

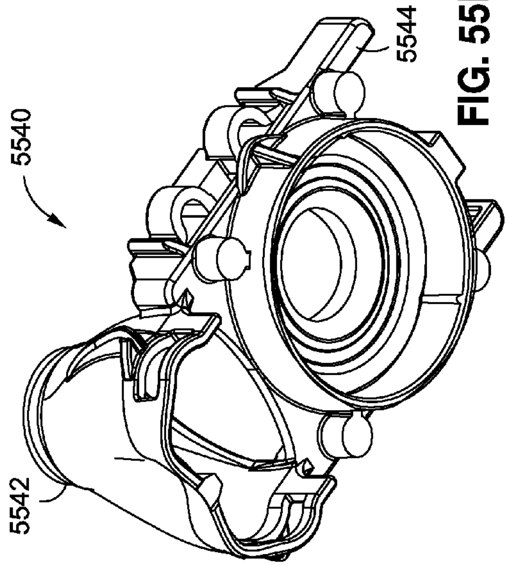


FIG. 55F

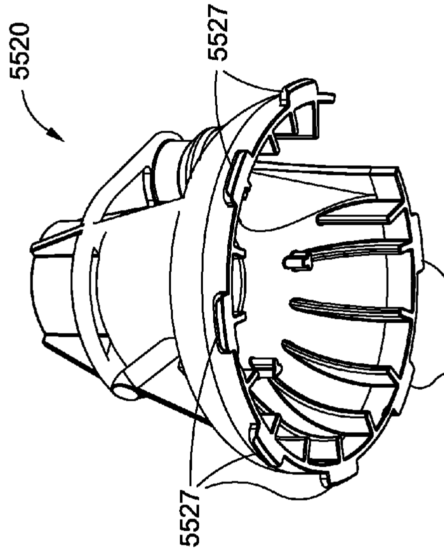


FIG. 55C

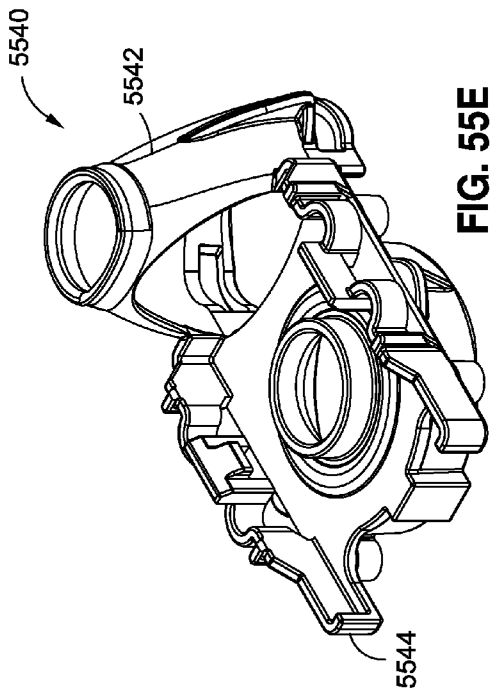


FIG. 55E

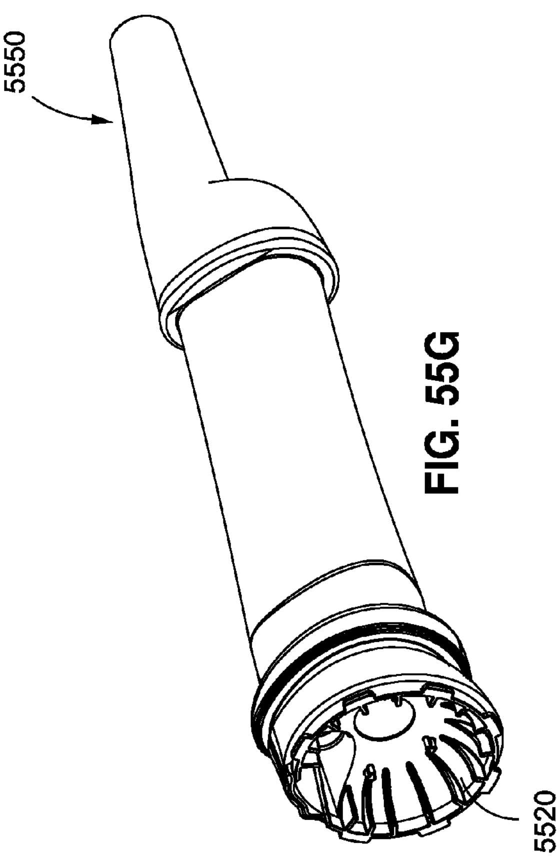


FIG. 55G

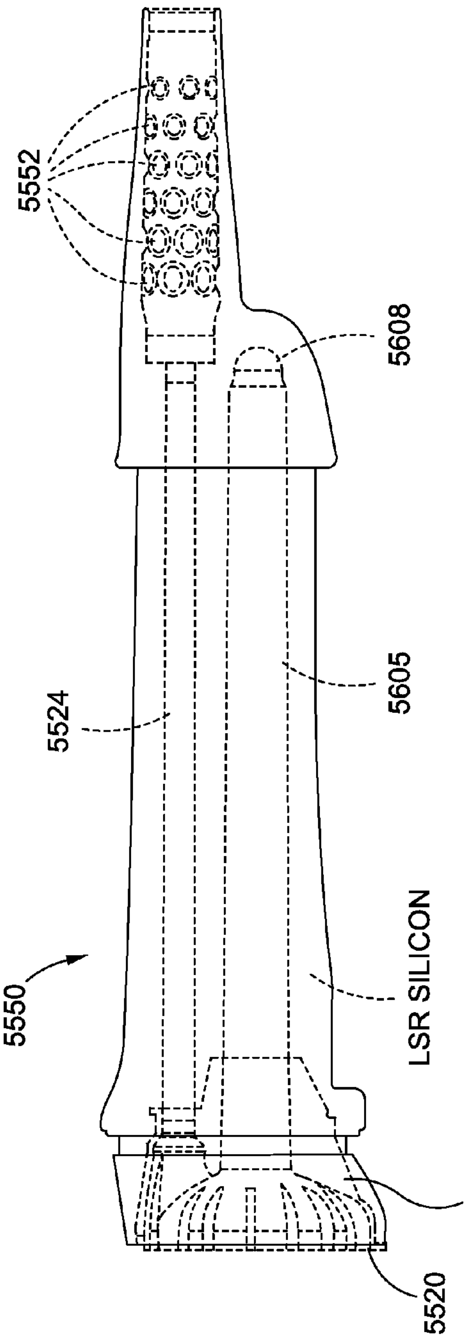


FIG. 55H

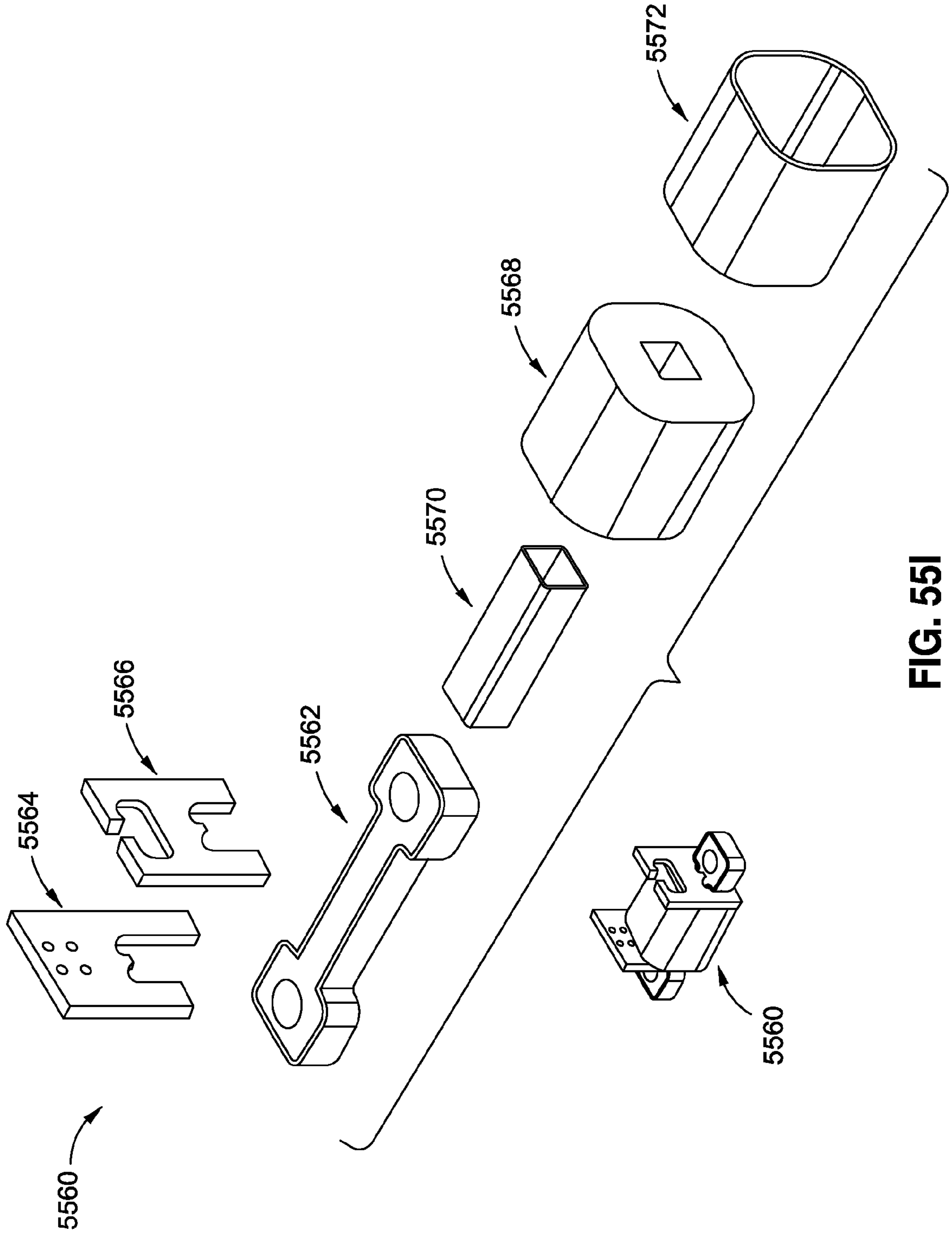


FIG. 55I

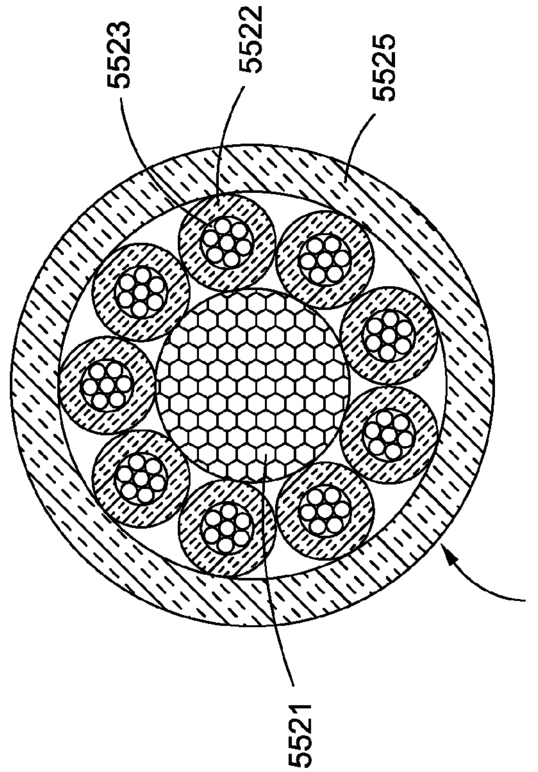


FIG. 55K

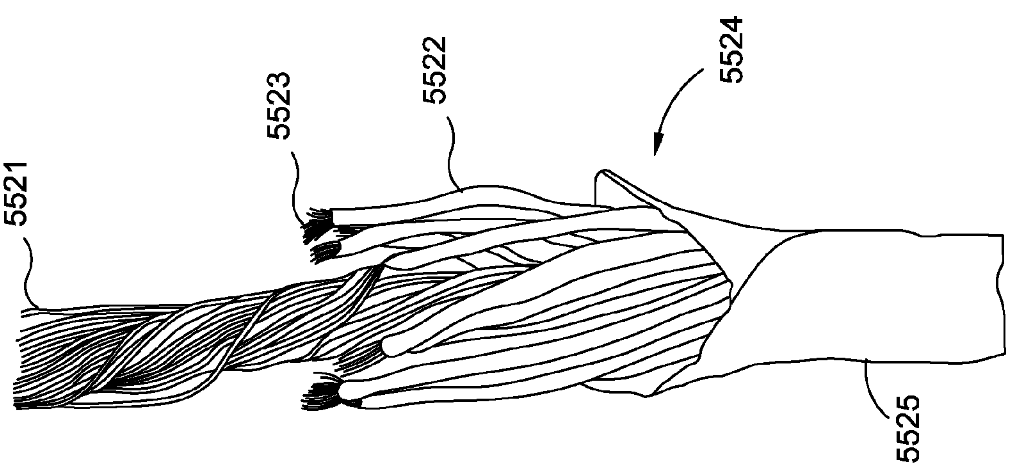


FIG. 55J

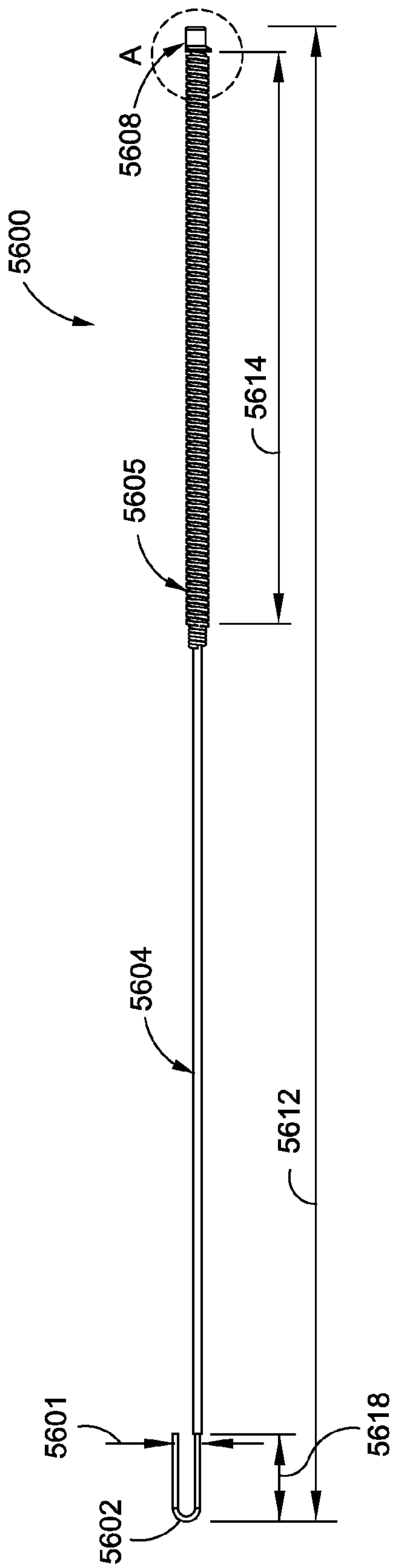


FIG. 56

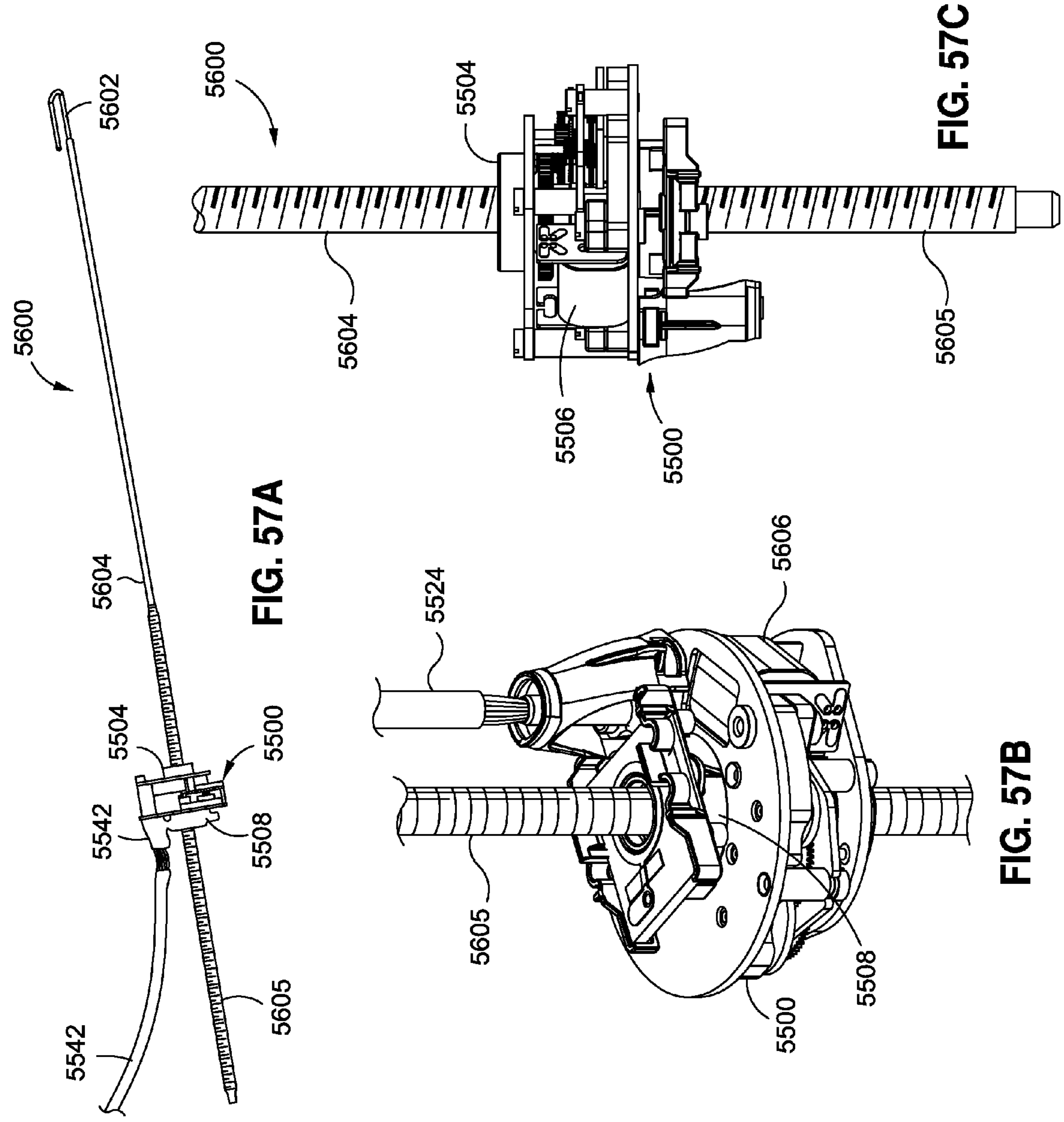


FIG. 57A

FIG. 57B

FIG. 57C

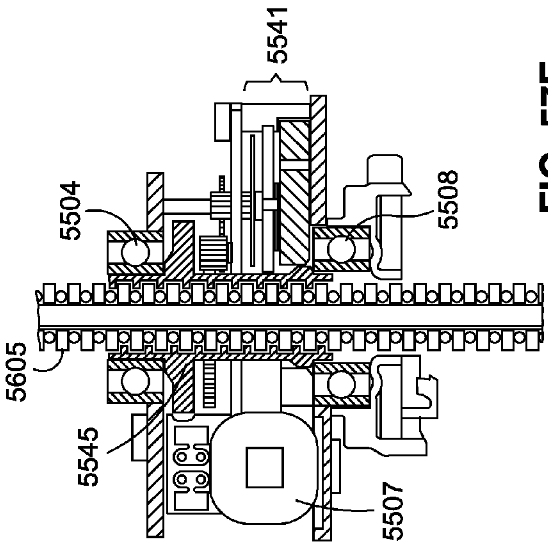


FIG. 57E

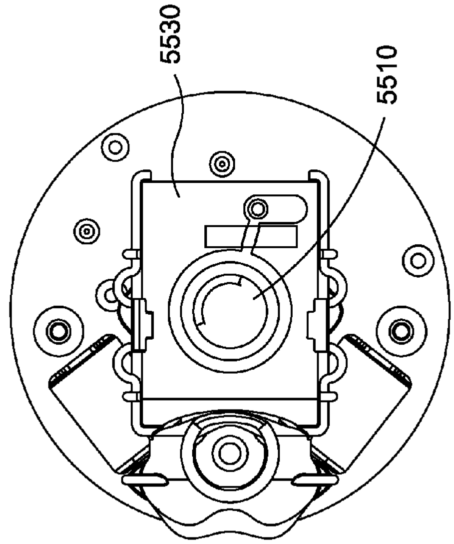


FIG. 57G

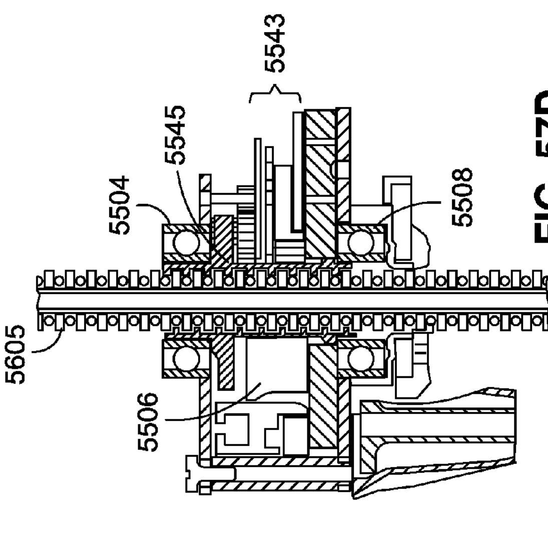


FIG. 57D

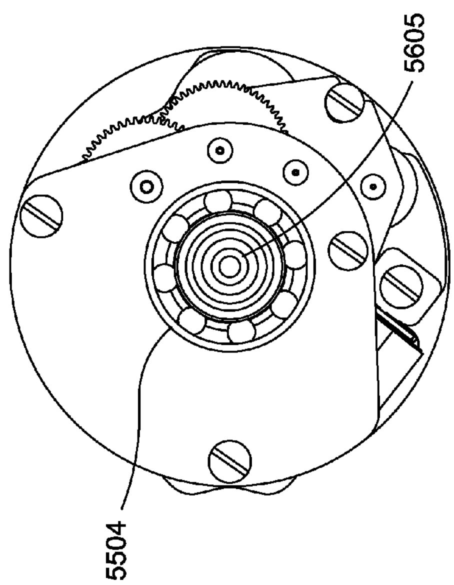


FIG. 57F

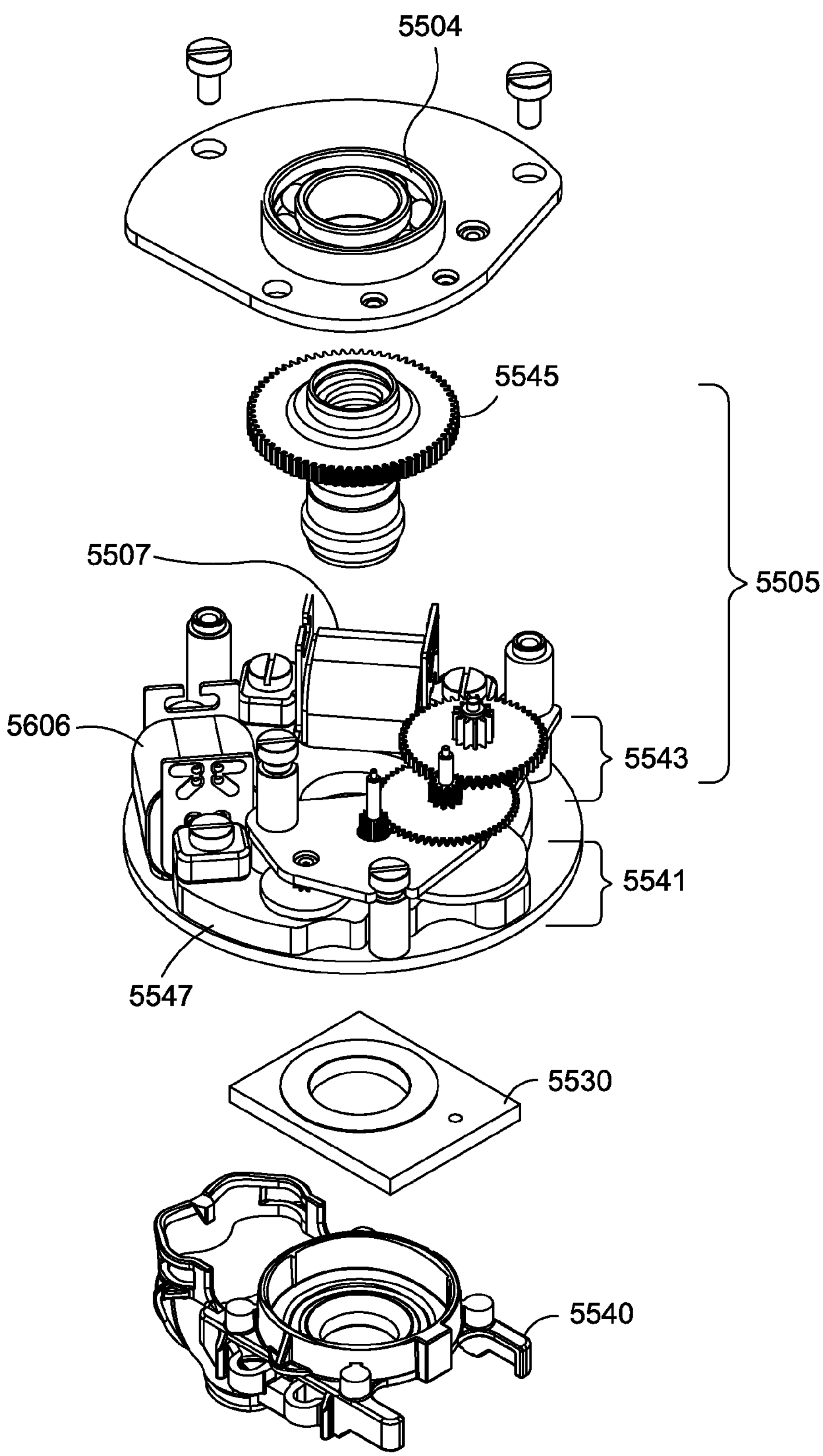


FIG. 57H

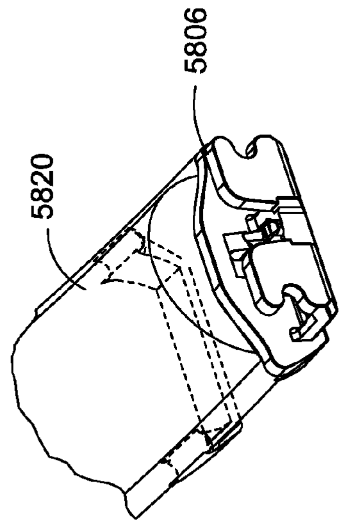


FIG. 58B

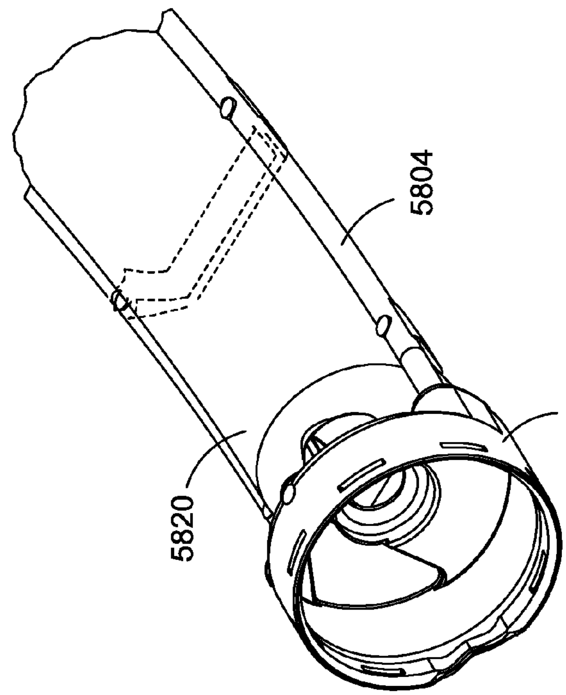


FIG. 58C

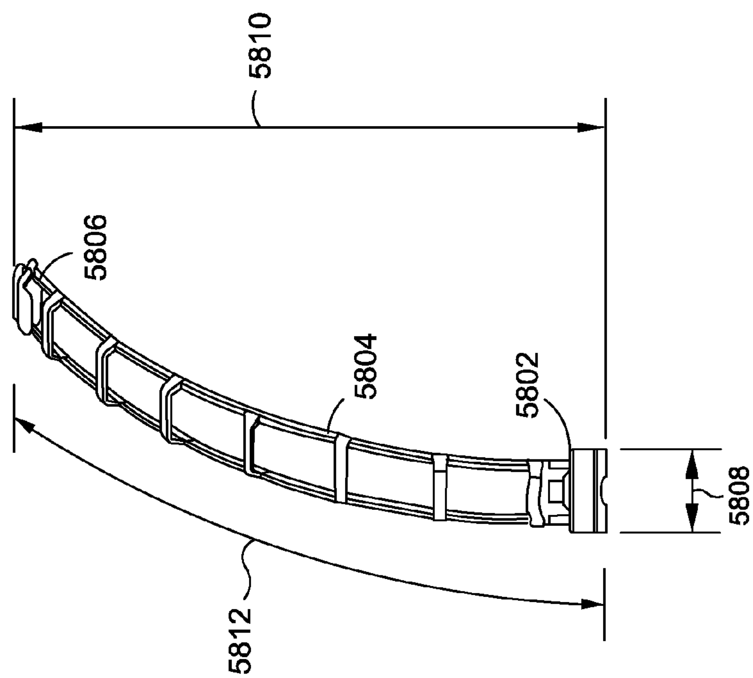


FIG. 58A

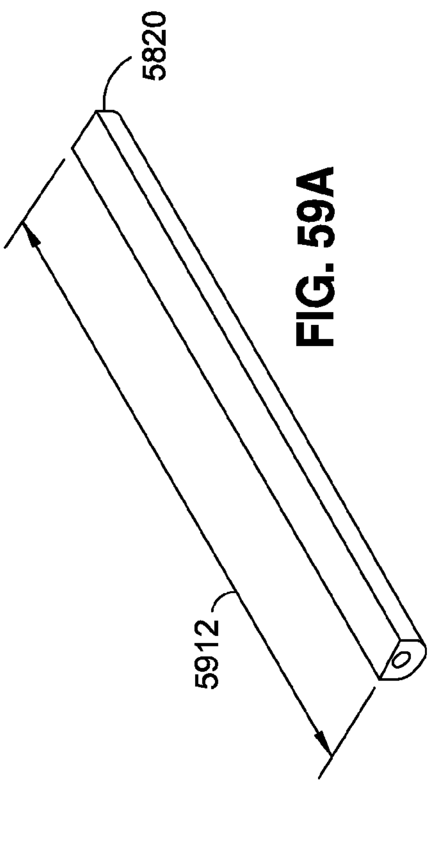


FIG. 59A

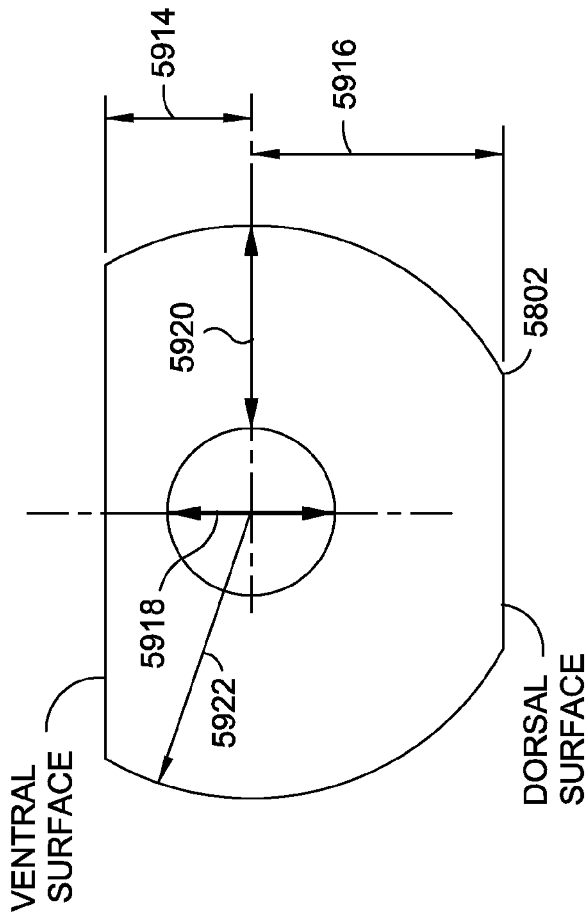


FIG. 59B

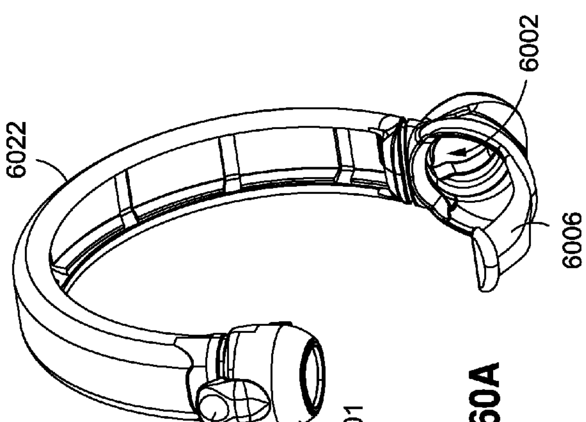


FIG. 60A

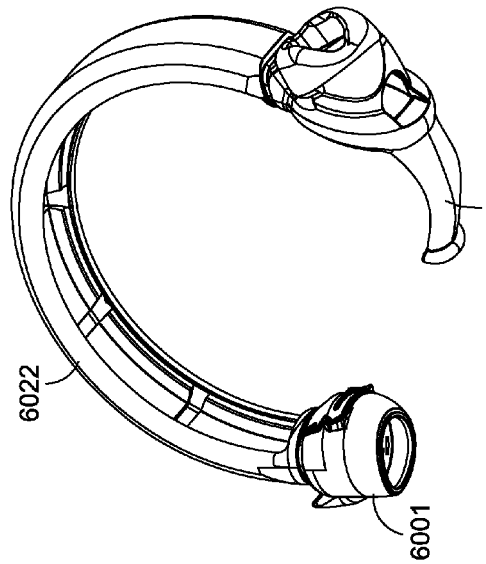


FIG. 60B

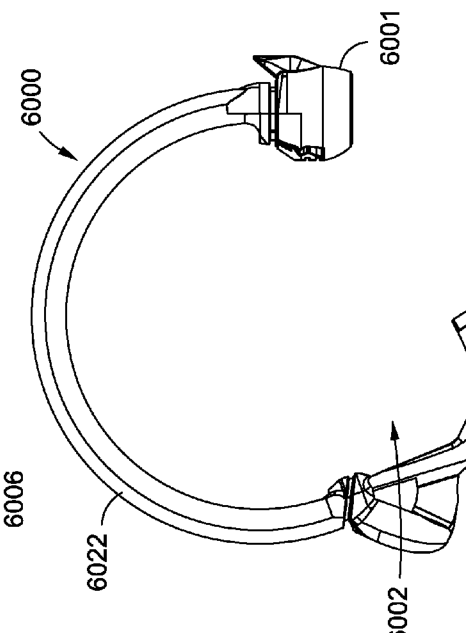


FIG. 60C

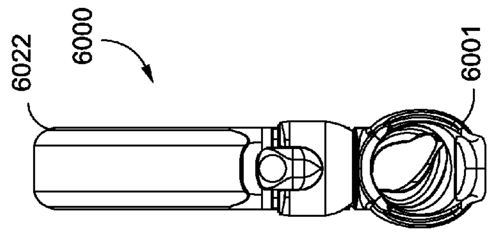


FIG. 60D

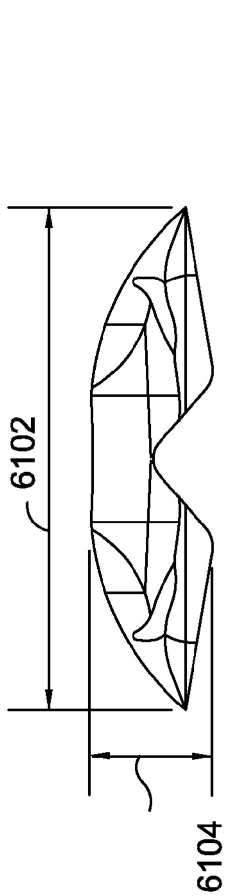


FIG. 61B

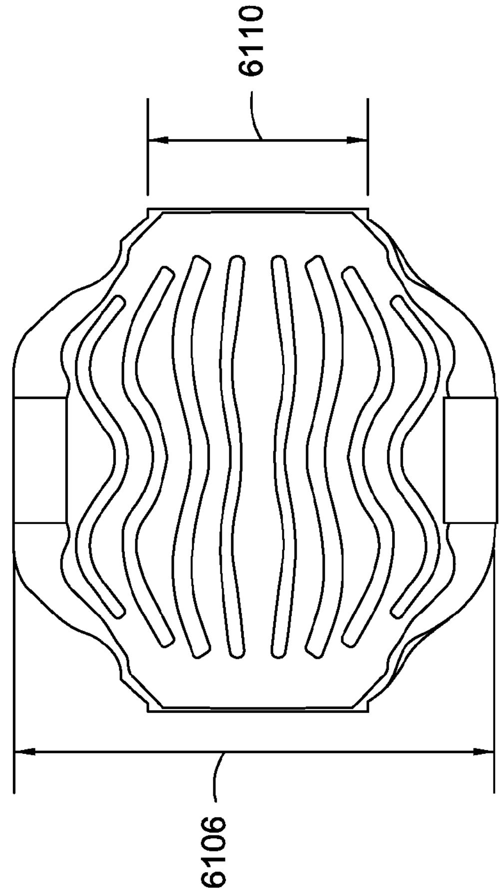


FIG. 61C

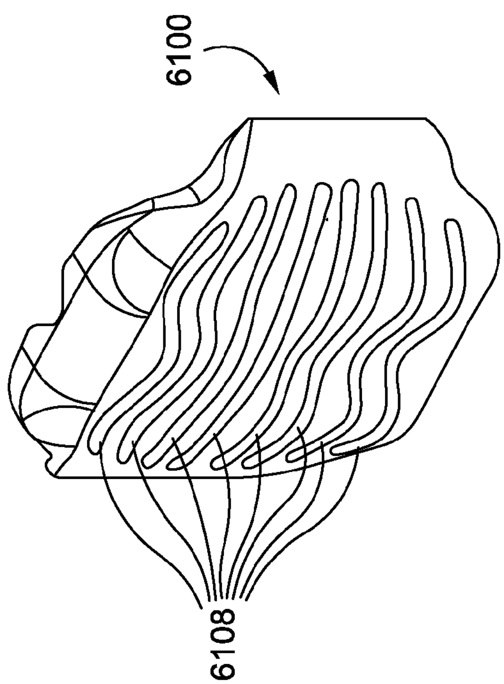


FIG. 61A

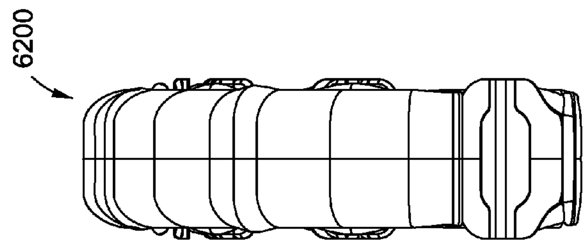


FIG. 62C

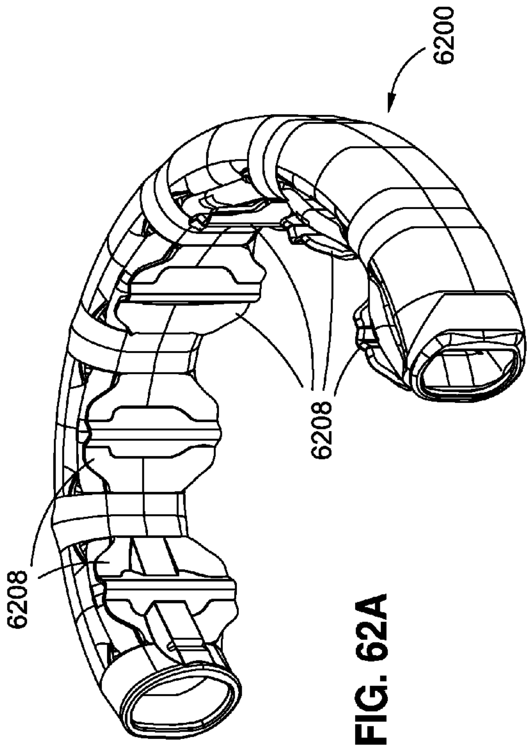


FIG. 62A

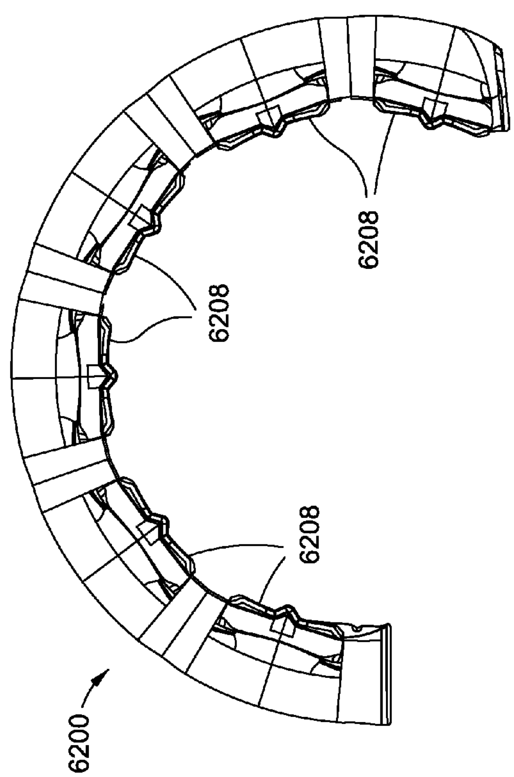


FIG. 62B

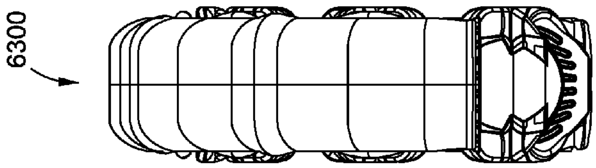


FIG. 63C

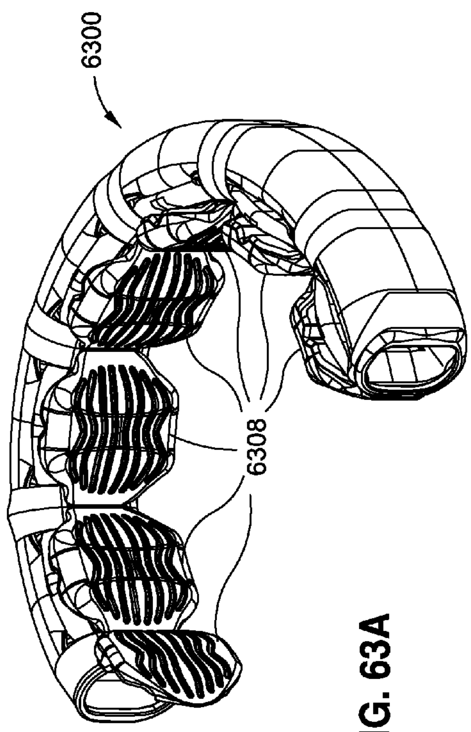


FIG. 63A

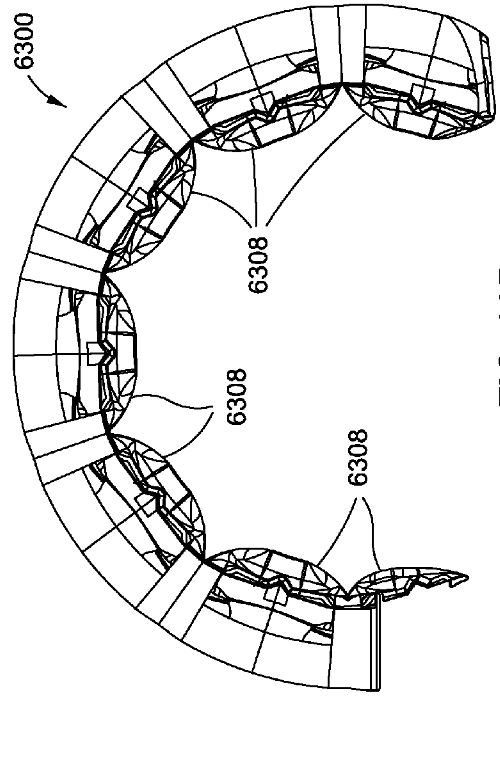


FIG. 63B

REMOTELY POWERED REMOTELY ADJUSTABLE GASTRIC BAND SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 13/076,139, filed Mar. 30, 2011, which claims priority to and the benefit of U.S. Provisional Application No. 61/343,571, filed on Apr. 30, 2010, which is assigned to the assignee hereof and hereby expressly incorporated by reference herein.

FIELD

The present invention generally relates to medical systems and apparatus and uses thereof for treating obesity and/or obesity-related diseases, and more specifically, related to gastric band systems that are remotely adjustable and remotely powered by a wireless control device.

BACKGROUND

Adjustable gastric banding apparatus have provided an effective and substantially less invasive alternative to gastric bypass surgery and other conventional surgical weight loss procedures. Despite the positive outcomes of invasive weight loss procedures, such as gastric bypass surgery, it has been recognized that sustained weight loss can be achieved through a laparoscopically-placed gastric band, for example, the LAP-BAND® (Allergan, Inc., Irvine, Calif.) gastric band or the LAP-BAND AP® (Allergan, Inc., Irvine, Calif.) gastric band. Generally, gastric bands are placed about the cardia, or upper portion, of a patient's stomach forming a stoma that restricts the passage of food into a lower portion of the stomach. When the stoma is of an appropriate size that is restricted by a gastric band, food held in the upper portion of the stomach provides a feeling of satiety or fullness that discourages overeating. Unlike gastric bypass procedures, the gastric band apparatus are reversible and require no permanent modification to the gastrointestinal tract.

Over time, a stoma created by a gastric band may need adjustment in order to maintain an appropriate size, which is neither too restrictive nor too passive. Some non-invasive procedures for adjustment of gastric bands without the use of a hypodermic needle have been proposed. For example, a remotely adjustable gastric band is a medical device which allows a healthcare worker to adjust a gastric band without requiring hypodermic needles to connect to an implanted, subcutaneous access port. A handheld controller can be used to send radio frequency waves for powering and communicating with the implanted device. The implanted device can tighten or relax the gastric band as requested by the healthcare worker via the handheld controller.

Birk, et al., U.S. Patent Pub. No. 2010-0010291, and Birk, et al., U.S. Ser. No. 12/705,245, which are commonly-assigned and co-pending with the present application, are incorporated herein in their entirety by this specific reference. Both of these applications disclose certain approaches to implantable systems that may be relevant.

Some mechanically adjustable implantable devices have a disadvantage of becoming inoperable if the adjustment mechanism fails. Furthermore, because the motor and the driving mechanisms are located near the restricting band itself, they are more subject to strain and damage from the implantation process. Therefore, it is desirable to develop a remotely adjustable gastric band where the motor is separated

from the restricting band to reduce the strain from the implantation process such that the risk of damage during implantation is decreased.

Thus, there continues to remain a need for more effective implantable motor systems for use with adjustable gastric bands, particularly such implantable motor systems with increased and more efficient motoring capability.

SUMMARY

Generally described herein are remotely adjustable and remotely powered gastric band systems, and methods of use thereof. The apparatus, systems and methods described herein aid in facilitating obesity control and/or treating obesity related diseases while being non-invasive once implanted.

In one embodiment, the present may provide a power system for use in conjunction with a gastric band coupled with an implantable antenna for receiving a telemetric signal from a remote control device. The power system may include a rectifying device coupled to the implantable antenna, and configured to rectify the received telemetric signal to form a DC input voltage at a DC input node, a power sensing device configured to receive the DC input voltage and generate a regulation signal when the DC input voltage exceeds a predetermined threshold, a regulation device coupled to the power sensing device, and configured to generate a regulation voltage based on the regulation signal, and a switching device coupled to the regulation device, and configured to generate a feedback signal having a frequency based on the regulation voltage.

In another embodiment, the present invention may provide a communication system for use in conjunction with a gastric band coupled with an implantable antenna for receiving a telemetric signal from a remote control device. The communication system may include a regulation device configured to generate a regulation voltage at a first node, the regulation voltage based on a margin between a DC input voltage and a predetermined threshold, a data path arranged in parallel with the regulation device, and configured to adjust the regulation voltage to a set voltage at a second node, the set voltage based partially on an output data sequence, and a frequency modulation device coupled to the second node, and configured to generate a frequency modulation signal having a modulated frequency corresponding to the set voltage.

In another embodiment, the present invention may provide a remotely powered and remotely adjustable gastric band system, which may include a remote control device configured to transmit a telemetric signal having an amplitude and a carrier frequency, an implantable power device telemetrically coupled to the remote control device, and configured to extract power from the telemetric signal and generate a feedback signal having a message frequency based on the extracted power, and a gastric band for forming a ventral ring surface around a stomach of a patient, the gastric band coupled to the implantable power device, and configured to receive the extracted power from the implantable power device and adjust the ventral ring surface in response to the telemetric signal.

In another embodiment, the present invention may provide a method for detecting motor blockage of a motor for use in conjunction with an implantable gastric band. The motor may include a motor coil for conducting a motor coil current and a plurality of gears for adjusting an inner ring surface of the implantable gastric band in response to the motor coil current. The method may include the steps of applying a voltage pulse across the motor coil, measuring a plurality of transient motor

coil currents, measuring a maximum motor coil current, and detecting the motor blockage based on the plurality of transient motor coil currents and the maximum motor coil current.

In another embodiment, the present invention may provide a tangible computer medium for storing instructions, upon being executed by a processor, that cause the processor to perform a method, which may comprise the steps of receiving measurements of a plurality of transient motor coil currents conducted by a motor coil of a motor for use in conjunction with an implantable gastric band, receiving a measurement of a maximum motor coil current conducted by the motor coil, and detecting a blockage of the motor based on the measurements of the plurality of transient motor coil currents and the measurement of the maximum motor coil current.

In another embodiment, the present invention may provide a motorized gastric band system, which may include an implantable gastric band for forming a loop having a ventral surface for contacting a stomach of a patient, a motor coupled to the implantable gastric band, and including a motor coil for conducting a motor coil current, and a gear responsive to the motor coil current, and for adjusting the ventral surface of the implantable gastric band, and a processor coupled to the motor, and configured to receive measurements of a plurality of transient motor coil currents conducted by the motor coil, receive a measurement of a maximum motor coil current conducted by the motor coil, and detect a blockage of the motor based on the measurements of the plurality of transient motor coil currents and the measurement of the maximum motor coil current.

In another embodiment, the present invention may include a retractable antenna device for a remotely adjustable and remotely powered an implantable gastric band. The retractable antenna device may include a housing having a top wall and a bottom wall, a winding drum disposed within the housing and along the axle, the winding drum having a neck and a base, the winding drum is configured to rotate about an axis between a first position and a second position, an antenna disposed between the base of the winding drum and the bottom wall of the housing, a cable configured to coil around the neck of the winding drum when the winding drum is at the first position, and configured to uncoil and substantially extend outside of the housing when the winding drum is at the second position, and a locking device configured to lock the winding drum when the winding drum rotates from the first position to reach the second position, so that the winding drum remains stationary at the second position.

In another embodiment, the present invention may provide a remote control device for use in conjunction with a remotely adjustable and remotely powered implantable gastric band. The remote control device may include a handle, a display screen having a proximal side and a distal side, the proximal side positioned between the handle and the distal side, a sensing device configured to determine an orientation of the remote control device by sensing the relative position of the distal side and the proximal side of the display screen, and a processing device coupled to the sensing device, configured to transmit a display signal to the display screen for displaying an image on the display screen with a first image orientation or a second image orientation depending on the orientation of the remote control device, and configured to adjust the implantable gastric band.

In another embodiment, the present invention may provide a system for rapidly charging a remote control device for remotely adjusting and powering an implantable gastric band via a telemetric coupling. The system may include a battery for providing power to the remote control device, and having a battery voltage, and a charging station for charging the battery, the charging station configured to monitor the battery voltage of the battery, deliver a constant charging current to the battery until the battery voltage reaches a predefined threshold, and deliver a constant charging voltage to the remote control device thereafter to maintain the battery voltage.

In another embodiment, the present invention may provide a system for remotely adjusting and powering an implantable gastric band configured to be installed around a stomach of a patient. The system may include an implantable memory configured to be disposed inside the patient and to store a patient record relatable to the patient and an adjustment record relatable to an adjustment history of the implantable gastric band, and a processor coupled to the memory, and configured to retrieve the adjustment history upon receiving a telemetric data retrieval signal from a remote control device, generate a signal for adjusting the implantable gastric band upon receiving a telemetric band adjustment signal from the remote control device, and update the adjustment record based on the telemetric band adjustment signal.

In yet another embodiment, the present invention may provide an implantable gastric band, which may include a tubular member having a first end and a second end, the second end defining an opening, the first end having a flange configured to engage the second end of the tubular member, thereby forming a tubular ring having an adjustable ventral ring surface and a substantially rigid dorsal ring surface, a skeleton disposed between the adjustable ventral ring surface and the substantially rigid dorsal ring surface of the tubular ring, the skeleton having a distal end pushing against the first end of the tubular member and a proximal end pushing against the second end of the tubular member, the skeleton configured to support the substantially rigid dorsal ring surface of the tubular ring, a flexible screw slid between the skeleton and the adjustable ventral ring surface, the flexible screw having a hook anchoring the distal end of the skeleton and a crimped end extending beyond the opening of the tubular member, the flexible screw having an outer portion disposed outside of the tubular ring and an inner portion disposed inside of the tubular ring, the inner portion of the flexible screw defining a circumference of the adjustable ventral ring surface, a motor anchoring the proximal end of the skeleton and engaging the flexible screw, and configured to increase or decrease the inner portion of the flexible screw, thereby adjusting the circumference of the adjustable ventral ring surface, a processor for receiving an telemetric signal and for controlling the motor, and a cable having a processor end coupled to the processor and a motor end coupled to the motor.

BRIEF DESCRIPTION OF THE DRAWINGS

The features, objects, and advantages of the invention will become more apparent from the detailed description set forth below when taken in conjunction with the drawings, wherein:

FIG. **1** shows a perspective view of a remotely adjustable remotely powered (RARP) gastric band system according to an embodiment of the present invention;

FIG. **2** shows a perspective view of various external components of the RARP gastric band system according to an embodiment of the present invention;

FIG. **3** shows a block diagram of the RARP gastric band system according to an embodiment of the present invention;

FIG. **4** shows a system architecture block diagram of the RARP gastric band system according to an embodiment of the present invention;

FIGS. **5**A-**5**B show the button configuration and display screen orientation of a control device according to an embodiment of the present invention;

FIG. **6** shows an exploded view of a control device according to an embodiment of the present invention;

FIG. **7** shows the perspective bottom and top views of a Human Interface Device (HID) Printed Circuit Board (PCB) being coupled to a Radio Frequency (RF) Printed Circuit Board (PCB) according to an embodiment of the present invention;

FIGS. **8**A-**8**R show the sample screen shots of the control device according to an embodiment of the present invention;

FIG. **9** shows a schematic view of the HID subsystem according to an embodiment of the present invention;

FIG. **10** shows a perspective view of the HID PCB components and connectors according to an embodiment of the present invention;

FIG. **11** shows a schematic view of the RF subsystem according to an embodiment of the present invention;

FIG. **12** shows a perspective view of the RF PCB components and connectors according to an embodiment of the present invention;

FIG. **13** shows a schematic view of a power regulation subsystem of the RARP gastric band system according to an embodiment of the present invention;

FIG. **14** shows a schematic view of a modulation device according to an embodiment of the present invention;

FIG. **15** shows a diagram with an ideal voltage curve and an ideal current curve of a Class E amplifier according to an embodiment of the present invention;

FIG. **16** shows the adjustability of tail end of the voltage curve in the Class E amplifier according to an embodiment of the present invention;

FIG. **17** shows a schematic view of a rectifying device according to an embodiment of the present invention;

FIG. **18** shows an implant power regulation subsystem according to an embodiment of the present invention;

FIG. **19** shows various waveforms of various signals of the implant power regulation subsystem according to an embodiment of the present invention;

FIG. **20** shows various waveforms of a double modulation (frequency modulated amplitude modulation) scheme according to an embodiment of the present invention;

FIG. **21** shows a schematic view of a double modulation subsystem according to an embodiment of the present invention;

FIG. **22** shows a frequency chart of the double modulation scheme according to an embodiment of the present invention;

FIG. **23**A shows a frequency spectrum of the frequency modulation feedback signal according to an embodiment of the present invention;

FIG. **23**B shows a demodulation of the frequency modulated amplitude modulation signal according to an embodiment of the present invention;

FIG. **24** shows a schematic view of a demodulation device according to an embodiment of the present invention;

FIG. **25** shows the relationship among various signals of the demodulation device and a distance between the external antenna and the implant antenna according to an embodiment of the present invention;

FIG. **26** shows the communication protocol among the HID subsystem, RF subsystem and the implant according to an embodiment of the present invention;

FIG. **27** shows the state diagram of an HID subsystem algorithm according to an embodiment of the present invention;

FIG. **28** shows the state diagram of an RF subsystem algorithm according to an embodiment of the present invention;

FIG. **29**A shows a command only communication protocol between the HID and RF subsystems according to an embodiment of the present invention;

FIG. **29**B shows a command-data communication protocol between the HID and RF subsystems according to an embodiment of the present invention;

FIG. **30** shows an answer message communication protocol from the RF subsystem according to an embodiment of the present invention;

FIG. **31** shows a notification message communication protocol from the RF subsystem according to an embodiment of the present invention;

FIGS. **32**A-**32**C show an exploded view, a front view and a back view of a docking station according to an embodiment of the present invention;

FIG. **33** shows a schematic view of the docking station interacting with the RF Board according to an embodiment of the present invention;

FIG. **34** shows a fast charge mode voltage-current chart according to an embodiment of the present invention;

FIGS. **35**A-**35**B show a perspective view and an exploded view of an external antenna with a retractable cable according to an embodiment of the present invention;

FIGS. **36**A-**36**B show a perspective front view and a perspective back view of the retractable external antenna being stored at the back of the control device according to an embodiment of the present invention;

FIGS. **37**A-**37**B show a perspective view and an exploded view of the implant according to an embodiment of the present invention;

FIGS. **38**A-**38**F show the perspective views of various implant electronic device protection case components according to an embodiment of the present invention;

FIGS. **39**A-**39**B show a top view and a bottom view of an implant electronic system board according to an embodiment of the present invention;

FIGS. **40**A-**40**C show various views of a manipulation handle according to an embodiment of the present invention;

FIG. **41** shows a state diagram of implant electronic device software algorithm according to an embodiment of the present invention;

FIGS. **42**A-**42**B show a transmission sequence and a data structure of an identification message to the control device according to an embodiment of the present invention;

FIGS. **43**A-**43**B show the command only protocol and a data structure of the command according to an embodiment of the present invention;

FIGS. **44**A-**44**B show the command-parameter protocol and a data structure of the command-parameter according to an embodiment of the present invention;

FIGS. **45**A-**45**B show the data structures of an ACK message and a NACK message according to an embodiment of the present invention;

FIG. **46**A shows a command-response protocol according to an embodiment of the present invention;

FIG. **46**B shows a data structure of a response message according to an embodiment of the present invention;

FIG. **47**A shows a time out protocol with control device checksum according to an embodiment of the present invention;

FIG. **47**B shows a time out protocol with implant checksum according to an embodiment of the present invention;

FIG. **48** shows a data structure of implant adjustment history record according to an embodiment of the present invention;

FIG. **49** shows a timing diagram of a computer interrupt upon a detection of a control device command at the implant according to an embodiment of the present invention;

FIG. **50** shows a timing diagram of the control device's command and the implant's response according to an embodiment of the present invention;

FIG. **51** shows a schematic view of a motor coil current measurement system according to an embodiment of the present invention;

FIG. **52** shows a graph for measuring an integral motor coil current according to an embodiment of the present invention;

FIG. **53** shows a graph for measuring a maximum motor coil current according to an embodiment of the present invention;

FIG. **54** shows a software algorithm for detecting motor blockage according to an embodiment of the present invention;

FIGS. **55**A-**55**B show a perspective top view and a perspective bottom view of a motor according to an embodiment of the present invention;

FIGS. **55**C-**55**D show a perspective bottom view and a perspective top view of a motor cap according to an embodiment of the present invention;

FIGS. **55**E-**55**F show a perspective bottom view and a perspective top view of a motor traveling PCB protection cap according to an embodiment of the present invention;

FIGS. **55**G-**55**H show a perspective side view and a side view of a motor sleeve according to an embodiment of the present invention;

FIG. **55**I shows an exploded view of a motor coil according to an embodiment of the present invention;

FIGS. **55**J-**55**K show various views of the motor cable according to an embodiment of the present invention;

FIG. **56** shows a side view of a flexible screw according to an embodiment of the present invention;

FIGS. **57**A-**57**H show various views of the motor engaging the flexible screw according to an embodiment of the present invention;

FIGS. **58**A-**58**C show various views of a bendable skeleton embedded with a stabilizing tube according to an embodiment of the present invention;

FIGS. **59**A-**59**B show a perspective view and a cross-sectional view of the stabilizing tube according to an embodiment of the present invention;

FIGS. **60**A-**60**D show various views of a dorsal element according to an embodiment of the present invention;

FIGS. **61**A-**61**C show various views of an anti-slip cushion according to an embodiment of the present invention;

FIGS. **62**A-**62**C show various views of a membrane shell according to an embodiment of the present invention; and

FIGS. **63**A-**63**C show various views of a cushioned membrane shell according to an embodiment of the present invention.

DETAILED DESCRIPTION

In FIG. **1**, a remotely adjustable and remotely powered (RARP) gastric band system **100** is shown according to an embodiment of the present invention. Generally, the RARP gastric band system **100** may include an external subsystem and an implant (internal) subsystem. The external subsystem may include a control device (a.k.a. control unit) **110**, an external antenna **120**, and a retractable antenna cable **114**, which may be used for coupling the external antenna **120** to the control device **110**.

From a high level standpoint, the control device **110** may serve various functions. In one embodiment, for example, the control device **110** may be used as an interface for a user, such as a physician or a care taker. In another embodiment, for example, the control device **110** may be used for transmitting telemetric signal **122** to the implant **130** for inducing power therein. In yet another embodiment, for example, the control device **110** may be used for remotely controlling various functionalities of the implant **130**, such as adjusting the size of a gastric band **180**, retrieving information from the implant memory device **150**, and/or regulating power inside the implant **130**.

The implant subsystem (a.k.a. the implant) **130** may be implanted inside a patient's body **101**, and it may include an implant electronic device **132**, a gastric band **180**, a motor **170**, and a motor cable **142**. The gastric band **180** may be used for forming a stoma around the patient's stomach **102**, and the motor **170** may be used for controlling the gastric band **180**, which may in turn, adjust the size of the stoma. Moreover, the implant electronic device **132** may include an implant (internal) antenna **160**, a microprocessor (a.k.a. microcontroller) **140**, and a memory device **150**.

From a high level standpoint, the microprocessor **140** may serve various functions. In one embodiment, for example, the microprocessor **140** may coordinate the reception, rectification, and regulation of power received via the implant antenna **160**. Generally, the implant antenna **160** may receive the signal transmitted from the external antenna **120** when they are separated by a distance of about 3 cm or less. In another embodiment, for example, the microprocessor **140** may retrieve past gastric band adjustment information from the memory device **150** or store current gastric band adjustment information to the memory device **150**. In yet another embodiment, for example, the microprocessor **140** may control the motor **170** for adjusting the gastric band **180**, and for detecting and preventing motor blockage.

In FIG. **2**, a perspective view of various external subsystem components of the RARP gastric band system **100** are shown according to various embodiments of the present invention. In addition to the control device **110** and the external antenna **120**, the external subsystem **200** may include a carrying case **201**, a power adaptor **202**, a power cord **204**, and a docking station **208**.

The power adaptor **202** may connect a power source (not shown) to the docking station **208**, such that the docking station **208** may receive electricity for charging the control device **110**. The external antenna **120** may be connected to the control device **110** (interchangeably "control unit") during gastric band adjustment. The external antenna **120** may be stored at the back of the control device **110** when it is not in use. In between gastric adjustments, the control device **110** may be docked at the docking station **208** for recharging. The connection between the control device **110** and the docking station **208** may be established by contacting several spring loaded connectors located on the docking station **208** with several matching metallic surfaces located on the control device **110**. The spring loaded connectors and the matching metallic surfaces may provide additional physical stability when the control device **206** is docked at the docking station **208**.

FIG. **3** shows a block diagram of a RARP gastric band system **300** according to an embodiment of the present invention. Generally, the RARP gastric band system **300** may include the control device **110**, the docking station **208**, the external antenna **120**, and the implant **130**. Particularly, the control device **110** may include a Human Interface Device (HID) board **310** and a Radio Frequency (RF) board **320**.

The HID board **310** may be used for implementing an HID subsystem. The HID subsystem may receive input from a user and generate output for the user during or in between gastric band adjustments. As such, a physician and/or a care taker may use the HID subsystem to adjust the size of the gastric band and to retrieve information regarding the gastric band adjustment history of a particular patient. The size of the gastric band can be understood as diameter of a ventral (inner) ring surface of the gastric band.

The RF board **320** may be used for implementing an RF subsystem. The RF subsystem may execute various tasks as instructed by the HID subsystem. Generally, the HID subsystem and the RF subsystem may setup a master-slave configuration **324**, in which the HID subsystem may command the RF subsystem to perform a recharging task, a power transmission task, a band adjustment task, and/or an information retrieval task.

To perform the recharging task, the RF subsystem may establish a power connection **326** with the docking station **208**. The power connection **326** may be used for transmitting power from the docking station **208** to the RF board **320**. Moreover, the power connection **326** may conduct signals that may be used for monitoring and controlling the recharge process.

To perform the power transmission task, the RF subsystem may drive the external antenna **120** with an RF signal that induces power in the implant **130**. Generally, the RF signal may be amplitude modulated and have a carrier frequency within the radio frequency range. In one embodiment, for example, the carrier frequency may range from about 30 kHz to about 300 GHz. In another embodiment, for example, the carrier frequency may range from about 10 MHz to about 50 MHz. In yet another embodiment, for example, the carrier frequency may approximately be about 27 MHz.

To perform the band adjustment task, the RF subsystem may momentarily transmit adjustment instruction via the external antenna **120** to the implant **130**. The transmission of the adjustment instruction may include a series of handshake protocols, which may ensure that the adjustment instruction is being received and executed properly by the implant **130**.

To perform the information retrieval task, the RF subsystem may sense and demodulate a feedback signal from the implant **130**. Generally, the feedback signal may be a double modulation signal, which may include a frequency modulation component and an amplitude modulation component. In one embodiment, for example, the frequency modulation component may be used for embedding gastric band adjustment data and power regulation signal while the amplitude modulation component may be used as a carrier. In another embodiment, for example, the amplitude modulation component may be used for embedding gastric band adjustment data and power regulation signal while the amplitude modulation component may be used as the carrier.

FIG. **4** shows a system architecture block diagram of a RARP gastric band system **400** according to an embodiment of the present invention. Generally, the RARP gastric band system **400** may include an external system **410** and an implant (internal) system **470**. The external system **410** may include an HID subsystem **420**, an RF subsystem **430**, an external antenna **440**, a docking station **450**, and a rechargeable battery **460**. The implant system **470** may include an implant antenna **472**, an RF transponder subsystem **473**, a power management subsystem **474**, an implant microcontroller (microprocessor) **476**, and a motor interface device **478**. The RF transponder subsystem **473** may include various electronic components connecting the antenna **472** and the microcontroller **476**. For example, the RF transponder subsystem **473** may include rectifying circuits and a LTC6900 chip.

The HID subsystem **420** may include: several input keys (buttons) **425** for receiving input from a user, a video device (OLED Display) **427** for outputting visual information to the user, an audio device **426** for outputting audio information to the user, a real-time control (RTC) device **424** for monitoring the charge level of the rechargeable battery **460**, an HID microcontroller (microprocessor) **421** for processing information received from the keys **425** and the RTC device **424**. In order to store and retrieve various data, the HID subsystem **420** may include several memory devices, such as a data flash device **428**, a serial flash device **422**, a SRAM device **423**, and an optional EEPROM device **429**.

The RF subsystem **430** may include: an EEPROM device **432** for storing various data, an RF microcontroller (microprocessor) **431** for performing various tasks requested by the HID microcontroller **421**, an RF transponder **434** for driving and receiving information from the external antenna **440**, and a battery management device **436** for interfacing with the docking station **450** and for controlling the recharging of the battery **460**.

FIGS. **5A-5B** show the button configuration and display screen orientation of a control device **500** according to an embodiment of the present invention. Generally, the front surface of the control device **500** may include a display screen **502**, a power button (sensor) **532**, a first set of auxiliary buttons (sensors) **504**, **506**, and **508**, a second set of auxiliary buttons (sensors) **534**, **536**, and **538**, and a set of adjustment control buttons (sensors), such as a band open button (sensor) **540**, a stop adjustment button (sensor) **542**, and a band close button (sensor) **544**.

The first and second set of auxiliary buttons **504**, **506**, **508**, **534**, **536**, and **538** may be configured to adapt to both left-handed and right-handed users. In one embodiment, for example, the button configuration and the display screen orientation as shown in FIG. **5A** may be used by a left-handed user. Particularly, in the left-handed configuration (orientation), the first set of auxiliary buttons **504**, **506**, and **508** may be inactivated or disabled, whereas the second set of auxiliary buttons **534**, **536**, and **538** may serve as the left, center, and right buttons, respectively.

In another embodiment, for example, the button configuration and the display screen orientation as shown in FIG. **5B** may be used by a right-handed user. Particularly, in the right-handed configuration, the second set of auxiliary buttons **534**, **536**, and **538** may be inactivated or disabled, whereas the first set of auxiliary buttons **504**, **506**, and **508** serve as the right, center, and left buttons, respectively.

As the first and second set of auxiliary buttons **504**, **506**, **508**, **534**, **536**, and **538** are being reconfigured, the display screen **502** may be reoriented as well. When the second set of auxiliary buttons **534**, **536**, and **538** are activated, the display screen **502** may have a first (left-handed) orientation as shown in FIG. **5A**. When the first set of auxiliary buttons **504**, **506**, and **508** are activated, the display screen **502** may have a second (right-handed) orientation as shown in FIG. **5B**. Generally, the control device **500** may have a gyroscopic device (not shown) for sensing its orientation. Particularly, the control device **500** may use the sensed orientation to generate one or more signals for reconfiguring the first and second set of auxiliary buttons **504**, **506**, **508**, **534**, **536**, and **538**, and for reorienting the display screen **502**.

FIG. **6** shows an exploded view of a control device **600** according to an embodiment of the present invention. The control device **600** may include a bottom shell **601**, a bottom shell lid **602**, a battery pack **603**, a left battery holder **604**, a right battery holder **605**, a metal plate **606**, a magnet **607**, a metal pad **608**, an RF PCB **609**, a regulatory sticker **610**, an

RF cable **611**, a top shell **612**, a bottom shell **613**, an adhesive display glass **614**, a display glass **615**, an auxiliary buttons group **616**, an adjustment control buttons group **617**, a power button **618**, a display OLED **619**, a Gasket display **620**, and an HID PCB **621**. As shown in FIG. **6**, the components of the control device can be grouped as the top shell assembly (right) and the bottom shell assembly (left). The two assemblies can be snapped or screen fastened together after the HID PCB **621** and the RF PCB **609** are properly coupled as shown in FIG. **7**.

FIGS. **8**A-**8**R show the sample screen shots of the control device according to an embodiment of the present invention. In FIG. **8**A, the control device may be powered up and it may display a "Welcome" screen, which include a logo and/or a slogan. In FIG. **8**B, the control device may display the "Code Entering" screen for receiving authentication information. In the "Code Entering" screen, a battery strength symbol **801** and a user code request message **802** may be displayed. Accordingly, a user may enter a four-digit access code **803**. Particularly, the user may use the left auxiliary button, which may be associated with the plus sign **804**, to increase the value of a digit, the center auxiliary button, which may be associated with the minus sign **805**, to decrease the digit value, and the right auxiliary button, which may be associated with the arrow sign **806**, to go to the next digit and eventually to accept the entry.

In FIG. **8**C, the control device may display the "Antenna Search" screen, in which the user may be instructed to place the external antenna near the implant antenna. A number of reception bars **807** may be shown in the "Antenna Search" screen once the control device detects a nearby implant antenna. The number of reception bars **807** may indicate the strength of the connection between the external antenna and the implant antenna. For example, a signal strength represented by two or less reception bars **807** may be considered insufficient, whereas a signal strength represented by three or more reception bars **807** may be considered sufficient.

In FIGS. **8**D and **8**E, the control device may display the "Loading" screens once the control device detects a signal strength represented by two or more reception bars **807**. The "Loading" screens may show the progress of downloading the patient's information from the implant.

Once the downloading is complete, the control device may display the "Adjustment" screen (a.k.a. "Default" screen) as shown in FIG. **8**F. In the "Adjustment" screen, the user may adjust the implanted gastric band. In adjusting the implanted gastric band, the user may use the band open button, which may be associated with the band open symbol **812**, and the band close button, which may be associated with the band close symbol **813**. Moreover, the user may choose to perform other functions. In one embodiment, for example, the user may use the left auxiliary button, which may be associated with the chart symbol **814**, to review the past adjustment history of a patient. In another embodiment, for example, the user may use the center auxiliary button, which may be associated with the code change symbol **815**, to change the password (or pass code) of the control device. In yet another embodiment, for example, the user may use the right auxiliary button, which may be associated with the lock symbol **816**, to lock the control device.

When the user presses or selects the open band button, the control device may display the "Opening" screen as shown in FIG. **8**G. In the "Opening" screen, the user may increase the size of the patient's stoma by loosening the implanted gastric band. Alternatively, when the user presses or selects the close band button, the control device may display the "Closing" screen as shown in FIG. **8**H. In the "Closing" screen, the user may decrease the size of the patient's stoma by tightening the implanted gastric band. The user may press the stop button to stop the loosening process or the tightening process to terminate the adjustment process, after which the "Adjustment" screen may be reloaded.

When the user selects the chart function, the control device may display the "Adjustment History Plot" screen as shown in FIG. **8**I. In the "Adjustment History Plot" screen, the user may use the left or center auxiliary button, which may be associated with the left and right arrow signs **818**, to view previous and/or current records. Alternatively, the user may use the right auxiliary button, which may be associated with the list symbol **817**, to view the adjustment history list.

When the user selects the adjustment history list, the control device may display the "Adjustment History List" screen as shown in FIG. **8**J. In the "Adjustment History List" screen, the user may use the left or center auxiliary button, which may be associated with the up and down arrow signs **818**, to view previous and/or current records. Alternatively, the user may use the right auxiliary button, which may be associated with the forward symbol **819**, to return to the "Adjustment History Plot" screen.

Referring again to FIG. **8**F, the user may lock the control device **110** by selecting the lock symbol **816**. When the control device **110** is locked, the control device may display the "Locked" screen as shown in FIG. **8**K. To exit the "Locked" screen, the user may press any button except for the power button. Then, the control device may display the "Code Entering" screen as shown in FIG. **8**B. In the "code entering" screen, the user may be instructed to enter the pass code again.

Referring again to FIG. **8**F, the user may change the old pass code by selecting the code change symbol **815**. As shown in FIG. **8**L, the control device may display the "Old Code Entering" screen, in which the user may enter the old pass code. After receiving and verifying the validity of the old pass code, the control device may display the "New Code Entering" screen as shown in FIG. **8**M. After receiving the new code **822**, the control device may display the "Confirm or Cancel Code" screen as shown in FIG. **8**N. At this point, the user may select the left auxiliary button, which may be associated with the OK symbol **804**, to accept the new code **822**, or select the right auxiliary button, which may be associated with the CANCEL symbol **825**, to cancel the new code **822**. Upon receiving the confirmation, the control device may display the "Code Changed" screen as shown in FIG. **8**O.

As shown in FIG. **8**P, the "Battery Recharge" screen may be displayed when the control device is being recharged. The "Adjustment" screen may return once the control device is disconnected from the docking station. FIGS. **8**Q and **8**K show the "Error Message" screens, which may notify the user with warning messages. For example, the "Error Message" screen may notify the user when the implant is malfunction or when the battery level is low.

Table 1 below may provide a summary of screen shot with respect to the button functionality.

TABLE 1

Button assignments for the different screen shots.

	Activated Auxiliary Buttons		
Screen shot	Left	Center	Right
Welcome	N/A	N/A	N/A
Code Entering	Increase value	Decrease value	Next digit
Antenna Search	N/A	N/A	N/A
Loading	N/A	N/A	N/A

TABLE 1-continued

Button assignments for the different screen shots.

Screen shot	Activated Auxiliary Buttons Left	Center	Right
Adjustment	History plot	Code Change	Lock
Opening	N/A	N/A	N/A
Closing	N/A	N/A	N/A
History Plot	Previous point	Next point	List
History List	Scroll up	Scroll down	Adjustment
Locked	Code entering	Code entering	Code entering
Old Code	Increase value	Decrease value	Next digit
New Code	Increase value	Decrease value	Next digit
Confirm Code	Confirm	N/A	Cancel
Code Changed	N/A	N/A	Adjustment
Battery Recharge	N/A	N/A	N/A
Error Message	Adjustment	N/A	N/A
Warning	N/A	Adjustment	N/A

Referring to FIG. **9**, a schematic view of the HID subsystem **900** is shown according to an embodiment of the present invention. Generally, the HID subsystem **900** may include eleven device blocks, such as a microcontroller block **902**, a memory block **904**, a display screen block **906**, a buzzer and vibrator block **908**, a sound interface block **910**, an accelerometer and RTC block **914**, an interface block **918**, a USB block **920**, an input button block **916**, a JTAG/TRACE connector block **922**, and a power supply block **912**.

Referring to FIG. **10**, a perspective view of the HID PCB **1000** is shown according to an embodiment of the present invention. Generally, each of the components on the HID PCB **1000** may be included in, associated with, or controlled by one of the eleven device blocks of the HID subsystem **900**.

The microcontroller block **902** may include the microcontroller device (microprocessor) **1004**, which may be configured as the master of the control device and may control all the user interface components, such as the display screen, the buttons, the sound interface, and the memory. The microcontroller block **902** may also include a crystal oscillator, two pull-down resistors and a pull-up resistor. The memory block **904** may include a 128-Mb flash memory **1034** and a 1-Mb EEPROM **1046**, along with five pull-up resistors and four regulating capacitors.

The display screen block **906** may include an OLED display, an OLED display flat connector **1048** and a display driver supply (not shown). The buzzer and vibrator block **908** may include various components for driving a buzzer **1038** and a vibrator **1008**. The sound interface block **910** may include an audio power amplifier **1010**, which may be connected to the speaker (not shown). The accelerometer and RTC block **914** may include an RTC chip **1041** and a PC30 accelerometer chip **1035** as well as a lithium ion battery **1044** for back-up power.

The input button block **916** may include a power button (not shown) for sending power up signals to the HID PCB and the RF PCB. The input button block **916** may also include two set of triplet buttons (auxiliary buttons) selectable by three output keys. The interface block **918** may include two connectors **1050** and **1052** for connecting cards together and for connecting between RF PCB. The USB block **920** may include two mini USB connectors **1020** and **1030**, an ESD input protection chip (not shown), and an RS232 translator chip FT232RL (not shown). The JTAG block **922** may include two connectors (not shown). Finally, the power block **912** may comprise a 3.3V voltage regulator (not shown) and several 3.3V power connections.

Referring to FIG. **11**, a schematic view of the RF subsystem **1100** is shown according to an embodiment of the present invention. Generally, the RF subsystem **1100** may include seven device blocks, such as a main controller block **1104**, a modulation block **1106**, a demodulation block **1108**, an auxiliary controller block **1110**, an RF power supplies block **1112**, a system power block **1101**, and a battery block **1102**.

Referring to FIG. **12**, a perspective view of the RF PCB **1200** is shown according to an embodiment of the present invention. Generally, each of the components on the HID PCB **1200** may be included in, associated with, or controlled by one of the seven device blocks of the RF subsystem **1100**.

The RF main controller block **1104** may include a microcontroller (processing device) **1201**, which may perform as a slave to the HID microcontroller block **902**. The RF microcontroller **1201** may control the power induction in the implant, the charging circuitry in the docking station, the communication to and from the implant, and the communication with the HID microcontroller block **902**. The RF microcontroller **1201** may further receive multiple monitoring inputs and the reset command from the HID microcontroller block **902**. The USB connection may be established through a mini USB connector **1274** with the USB protocol translated into a UART serial interface through an RS232 translator chip (not shown).

The modulation block **1106** may include a class E amplifier **1234** for generating an amplitude modulation signal with carrier frequency at about 27 MHz. Particularly, the modulation block **1106** may be involved in generating a 27 MHz carrier frequency with an amplitude that equals the RF supply voltage VSUP, while the data signal may contain the digital command being sent to the implant via the external antenna.

The demodulation block **1108** may include a FM demodulator chip **1208** to demodulate the signals received from the implant and extracted from the external antenna via a directional coupler **1272**. As such, the FM demodulator chip **1208** may be used for retrieving useful information, such as the received signal strength RSSI and the feedback message from the implant. The RF demodulator chip **1208** may also generate regulating signals, including REG_LEVEL, VSUP_CTRL, VSUP, and FORCE_RF_LEVEL.

The power supplies block may comprise a LT1961 voltage regulator (not shown), the amplitude of which may be controlled by either the VSUP_CTRL input indirectly from the implant or the DAC_IN input from the RF controller. The VSUP_CTRL input helps implement the control loop between the implant and the control device which adjusts the power induced in the implant. The RF microcontroller **1201** may also shutdown VSUP through the VSUP_ON/OFF input. Moreover, VSUP_INHIBIT1 may shutdown VSUP whenever the control device is powered from an external source to avoid any danger to the patient from power line surges. BSUP_INHIBIT2 may provide another shutdown path from the auxiliary controller block.

The auxiliary controller block **1110** may include an auxiliary controller **1244** and the associating connectors. The auxiliary controller **1244** may allow the overall system to implement a software oriented version of the implant power induction control.

The system power block **1101** may comprise the LM22672M voltage regulator **1256** for regulating the power supplies at 3.6V, the LP2985-33 voltage regulator U18 **1276** for regulating the power supplies at 3.3V, and several monitoring signals indicating the power being turned on (KON), the presence of external power (EXTPWR_PRESENT) and the current load to the battery (ILOAD). The battery block

1102 may include a battery management related circuitry **1268**, the battery connectors **1246** and **1264**, as well as two batteries connected in series, which may be monitored by the signals BATMON, BATMONZ, BATT_TH, EXT_BAT_ES1 and EXT_BAT_MES2.

The discussion now turns to the power regulation subsystem of the remotely adjustable remotely power (RARP) gastric band system. Referring to FIG. **13**, a schematic view of a power regulation subsystem **1300** is shown according to an embodiment of the present invention. Generally, the power regulation subsystem **1300** may be implemented by various devices (blocks) of the RF Board and of the Implant. The RF Board may include a modulation device (block) **1320**, an external antenna **1324**, a demodulation device (block) **1330**, a power supply device (block) **1340**, and a controller device (block) **1310**. The Implant may include an implantable antenna **1352**, a rectifying device (first device block) **1350**, a maximum power sensing device (second device block) **1360**, a regulation device (third device block) **1370**, and an impedance switching device (fourth device block) **1380**.

To initiate the power induction process, the controller device **1310** may send a transmission signal **1312** to enable the modulation device **1320**. Depending on the operation mode of the RF Board, the transmission signal **1312** can be activation based or interrupt based. After being enabled, the modulation device **1320** may generate an amplitude modulation signal for driving the external antenna node **1322**. The external antenna node **1322** may be a transmission line that couples between the external antenna **1324** and the modulation device **1320**. As a result, the external antenna **1324** may transmit a telemetric signal **1326** according to the amplitude modulation signal.

The telemetric signal **1326** may travel across air and penetrate the body tissue of the patient, such that it may be received by the implantable antenna **1352**. Based on the principles of electromagnetic induction, an alternate current (AC) may be induced at the implant antenna node **1354**. The rectifying device **1350** may rectify the voltage associate with the alternate current, so as to deliver a DC input voltage (V_{IN}) on the DC input voltage (V_{IN}) node **1356**. The maximum power sensing device **1360** may monitor the level of the DC input voltage V_{IN}. When the DC input voltage V_{IN} exceeds a certain predetermined threshold voltage value, the maximum power sensing device **1360** may generate a regulation signal **1362** to activate the regulation device **1370**.

After being activated, the regulation device **1370** may generate a regulation voltage **1372**. The magnitude of which may depend on a voltage difference (potential difference) between the DC input voltage V_{IN} and the predetermined threshold voltage value. Thus, the magnitude of the regulation voltage **1372** may represent or indicate the amount of regulation that may be needed. Generally, the DC input voltage V_{IN} may be a function of a transmission distance between the external antenna **1324** and the implantable antenna **1352**. When the transmission distance decreases, the signal strength of the telemetric signal **1326** may increase, thereby causing the DC input voltage V_{IN} to rise. Thus, as the external antenna **1324** approaches the implantable antenna **1352**, the regulation voltage **1372** may increase. In order to communicate the need to regulate with the RF Board, the regulation voltage **1362** may be used for generating one or more feedback signals and/or messages.

The impedance switching device (switching device) **1380** may receive and process the regulation voltage **1362**. After processing the regulation voltage **1362** along with other signals, the impedance switching device **1380** may couple and decouple the DC input voltage V_{IN} node **1356** to and from an additional impedance component at a feedback frequency. Generally, the feedback frequency may be determined based on the regulation voltage **1362** and some other factors. In one embodiment, for example, the feedback frequency may be inversely proportional to the regulation voltage **1362**. In another embodiment, for example, the feedback frequency may be directly proportional to the regulation voltage **1362**.

By switching on and off the additional impedance component, the impedance switching device **1380** may generate a feedback signal **1382**, which may superimpose the regular DC input voltage V_{IN}. That is, the overall load impedance (Z_{LOAD}) may be adjusted by the feedback frequency of feedback signal **1382**.

According to the principle of mutual inductance, the fluctuation of the overall load impedance and/or the feedback signal **1382** may manifest as a passive telemetric signal **1356**, which may be received by the external antenna **1324**. Consequently, the feedback frequency of the feedback signal may be seen as a message (envelop) frequency of the passive telemetric signal **1357**.

In order to separate the passive telemetric signal **1357** from the outbound amplitude modulation signal, the RF Board may use a sensing device (block) **1332** to sense or extract a feedback profile **1334** of the passive telemetric signal **1357** from the external antenna node **1322**. The feedback profile **1334** may have a frequency tracking the feedback frequency of the feedback signal. In one embodiment, for example, the sensing device **1332** may be a directional coupler. The demodulation device **1330** may receive the feedback profile **1334** and determine and/or extract the message frequency embedded in the feedback profile **1334**.

Consequentially, the demodulation device **1330** may generate a voltage supply control signal **1336** based on the feedback frequency. The power supply device **1340** may process the voltage supply control signal **1336** and regulate the RF supply voltage **1342** accordingly. Because the modulation device **1320** may be powered by the RF supply voltage **1342**, the amplitude modulation signal may be indirectly regulated by the power supply device **1340**. As a result, the power induced by the amplitude modulation signal may be increased or decreased depending on the feedback signal **1382**.

More specifically, the amplitude modulation signal may have a carrier frequency and a magnitude (modulation amplitude). Depending on the load impedance, the carrier frequency may be selected from a range of radio frequencies (about 30 kHz to about 300 GHz) for maximum power transfer. For example, the carrier frequency may be about 27 MHz when the load impedance is about 50Ω.

The modulation amplitude may be controlled by the RF supply voltage **1342**, and it may determine the amount of power being transferred from the RF Board to the implant. Thus, power transfer may be regulated by adjusting the modulation amplitude, which may depend on the RF supply voltage **1342**. For example, when the implant receives excessive power, which may cause overheating in the implant, the RF supply voltage **1342** may be lowered to reduce the modulation amplitude of the amplitude modulation signal. For another example, when the implant receives insufficient power, which may cause the implant to be turned off, the RF supply voltage **1342** may be augmented to increase the modulation amplitude of the amplitude modulation signal.

In FIG. **14**, a schematic view of a modulation device **1400** is shown according to an embodiment of the present invention. Generally, the modulation device **1400** may be used for implementing the functional features of the modulation device **1320**. Particularly, the modulation device **1400** may include an activation block (activation device path) **1430** for enabling or disabling the generation of the amplitude modulation signal, an oscillating device **1450** for generating a carrier frequency signal **1452**, and a class E amplifier block (amplifier device path) **1410** for generating the amplitude modulation signal **1420**. The oscillating device **1450** may be a crystal oscillator, and it may be used for controlling the carrier frequency of the amplitude modulated signal **1420**.

The activation block **1430** may include a first stage amplifier **1432** for amplifying the transmission signal **1312**, and a second stage amplifier **1434** for generating a data override signal **1436**. Generally, the carrier frequency signal **1452** may be buffered by a first stage inverter **1453** and a second stage inverter **1454**. Although the first stage inverter **1453** may be powered on by a separate power source, the second stage inverter **1454** may be enabled or disabled by the data override signal **1436**.

When the RF Board is powering the implant, the data override signal **1436** may be low, such that the carrier frequency signal **1452** may drive a switching node **1401**. Alternatively, when the RF Board is transmitting data, the data override signal **1436** may be high, such that the second inverter stage **1454** may be turned off momentarily during data transmission. As a result, the carrier frequency signal **1452** may be blocked from driving the switching node **1401**.

The class E amplifier block **1410** may have a common source stage **1404** for driving a first intermediate node **1402**. The output of the common source stage **1404** may have a frequency component, which may be controlled by the carrier frequency signal **1452** of the oscillating device **1450**, and an amplitude component, which may be controlled by the RF supply voltage **1342**. Depending on the regulation level, the amplitude component may change as the transmission distance varies. In one embodiment, for example, the amplitude component may range from about 3 V to about 16 V. In another embodiment, for example, the amplitude component may range from about 5V to about 14 V. As discussed earlier, the power induced in the Implant may be regulated by adjusting the amplitude component of the amplitude modulation signal **1420**, which may be dictated by the RF supply voltage **1342**.

Referring to FIG. **15**, the class E amplifier block **1410** may have a relatively low sensitivity to any variation in the load Z_L, and it may have a high efficiency as long as the transitions at the (common source state) MOS switch **1404** occur while the current or the voltage is null. Referring to FIG. **16**, the capacitor C2 and the impedance Zh2 may be the adjustable components in the amplifier block **1410**, such that the transition point may be moved left and/or right by adjusting the value of the capacitor C2, and it may be moved up and/or down by adjusting the value of the impedance Zh2.

In FIG. **17**, a schematic view of a rectifying device **1700** is shown according to an embodiment of the present invention. Generally, the rectifying device **1700** may implement the functional features of the rectifying device **1350** as discussed in FIG. **13**. Particularly, the rectifying device **1700** may include a first capacitor **1712**, a second capacitor **1714**, a first diode **1722**, and a second diode **1724**. More specifically, the first and second capacitors **1712** and **1714** may function as a pair of charge storage (or bootstrap) devices, while the first and second diodes **1722** and **1724** may function as a pair of voltage directing devices.

The modulation device **1320** may drive the external antenna **1324** with an amplitude modulation signal **1701**, which may generate an alternate current in the external antenna **1324**. As a result, electromagnetic waves may be emitted from the external antenna **1324**, and they may propagate through air and penetrate the body tissue of the patient. A

small portion of the electromagnetic waves may be absorbed by a secondary parasite **1704**, while a large portion of the electromagnetic waves may induce alternate voltage **1703** in the implantable antenna **1352**.

The amplitude of the induced voltage **1703** may be affected by a transmission distance **1720** separating the external antenna **1324** and the implantable antenna **1352**. For example, the amplitude of the induced voltage **1703** may decrease when the transmission distance **1720** increases from 10 mm to 20 mm. For another example, the amplitude of the induced voltage **1703** may increase when the transmission distance **1720** decreases from 35 mm to 20 mm.

The induced voltage **1703** may be rectified by the first and second diodes **1722** and **1724**. As a result, the output nodes **1730** of the rectifying device **1700** may deliver the DC input voltage (V_{IN}) **1705**. The two-diode configuration may allow the V_{IN} to have a relatively high magnitude, which may be slightly less than two times of the induced voltage **1703**. When the transmission distance **1702** is large (e.g. greater than 35 mm), it is advantageous to have the relative high magnitude V_{IN} to compensate the energy loss to the secondary parasite **1704**. However, when the transmission distance **1702** is small (e.g. less than 10 mm), the relative high magnitude V_{IN} may be problematic because it may produce excessive energy, which may lead to overheating within the implant.

To prevent overheating, the Implant may include a power regulation subsystem to provide feedback information to adjust the output energy of the modulation device. In FIG. **18**, an implant power regulation subsystem (a.k.a. the power system) **1800** is shown according to an embodiment of the present invention. Generally, the implant power regulation subsystem **1800** may include the maximum power sensing device (second device block) **1360**, the regulation device (third device block) **1370**, and the impedance switching device (fourth device block) **1380**.

The maximum power sensing device **1360** may include a Zener diode **1862** and a first pull down resistor **1844**. In one configuration, the positive terminal of the Zener diode **1862** may be coupled to the DC input voltage (V_{IN}) node and the negative terminal of the Zener diode **1862** may be coupled to the first pull down resistor **1844**, which may be coupled to an internal ground node. The Zener diode **1862** may have a breakdown voltage V_{BD} across its positive and negative terminals. When the DC input voltage (V_{IN}) is less than the breakdown voltage V_{BD}, the Zener diode **1862** may be under forward bias, such that the Zener diode **1862** is unlikely to sink any current from the DC input voltage (V_{IN}) node. As a result, the first pull down resistor **1864** may pull the regulation signal to ground.

However, when the DC input voltage (V_{IN}) reaches and/or exceeds the breakdown voltage V_{BD}, the Zener diode **1862** may be under reverse bias, such that the Zener diode **1862** may begin to draw a breakdown current I_{BD} from the DC input voltage (V_{IN}) node. As a result, the regulation signal **1362** may maintain a voltage level V_R across the first pull down resistor **1864**. Depending on the design goal, the breakdown voltage V_{BD} may be predetermined to accommodate the power consumption of the implant. That is, the breakdown voltage V_{BD} may be chosen at a range that is substantially equal to or close by the predetermined threshold voltage. In one embodiment, for example, the breakdown voltage V_{BD} may be about 3 V. In another embodiment, for example, the breakdown voltage V_{BD} may be about 7 V. In yet another embodiment, for example, the breakdown voltage V_{BD} may be about 5.6 V.

Although the sinking of the breakdown current I_{BD} may have little effect on the V_{IN} value, it may help generate the regulation signal **1362**. The voltage level V_R of the regulation signal **1362** may indicate or represent a desirable level of regulation. Mainly, the breakdown current I_{BD} may be highly sensitive to the change of V_{IN} value, so that the regulation signal voltage level V_R may track closely to the amount of the excessive DC input voltage V_{IN}.

The regulating device **1370** may include a voltage regulator **1872**, a first pull up resistor **1874**, a second pull up resistor **1875**, a transistor **1876**, and a second pull down resistor **1878**. The voltage regulator **1872** may be used for generating a relatively constant local voltage V_{CC} at a first node (e.g., the V_{CC} node). The constant local voltage V_{CC} may supply power to various electronic components of the implant. For example, the local voltage V_{CC} may supply power to the current path formed partially by the first and second pull up resistors **1874** and **1875**. Generally, the local voltage V_{CC} may be less than the DC input voltage V_{IN} and the predefined threshold voltage, which may be approximated by the breakdown voltage V_{BD} of the Zener diode **1862**.

When the regulation signal voltage level V_R is less than the threshold voltage of the transistor **1876**, there may be little or no regulation current I_R because the transistor **1876** is not conducting. As such, the regulation voltage V_{REG} may be substantially equal to the local voltage V_{CC}.

However, when the DC input voltage V_{IN} exceeds the breakdown voltage V_{BD} of the Zener diode **1862**, the regulation signal voltage level V_R may begin to rise, and eventually, it may overcome the threshold voltage of the transistor **1876**. As a result, the transistor **1876** may be turned on and draw the regulation current I_R. The regulation current I_R may cause a potential drop across the first pull up resistor **1874**, which is connected between the first node and a second node (e.g., the V_{REG} node). Consequently, the regulation voltage V_{REG} may decline as the regulation signal voltage level V_R increase. With the help of the pull up resistor **1874**, the regulation current I_R creates a regulation margin (i.e., potential difference) between the V_{CC} node and the V_{REG} node.

From the point where the transistor **1876** begins to conduct to the point where the transistor **1876** becomes saturated, the regulation voltage V_{REG} may achieve substantial linearity with the regulation signal voltage V_R, which may be driven primarily by the breakdown current I_{BR}. As such, the regulation device **1370** may perform the power regulation task when the DC input voltage V_{IN} exceeds the breakdown voltage V_{BD} by a regulation margin. The regulation margin may be represented by the voltage level V_R of the regulation signal **1362**. In one embodiment, for example, the regulation margin may range from about 0.05 V to about 10V. In another embodiment, for example, the regulation margin may range from about 0.1 V to about 5V. In yet another embodiment, for example, the regulation margin may range from about 1 V to about 3 V.

The transistor **1876** may amplify the regulation margin between the DC input voltage and the predefined threshold. As such, the potential difference between the local voltage V_{CC} and the regulation voltage V_{REG} may be highly responsive and sensitive to any slight change in the regulation margin.

After the regulation voltage V_{REG} begins to decline, the impedance switching device **1380** may be activated. Generally, the impedance switching device **1380** may include a frequency modulation device (block) **1820**, a switch **1840**, and an impedance component **1844**. The frequency modulation device **1880** may generate a frequency modulation signal **1822**. The frequency modulation signal **1822** may have a modulated frequency that is based on and/or represent the value of the regulation voltage V_{REG}. In one embodiment, for example, the modulated frequency of the frequency modulation signal **1822** may be directly proportional to the potential difference between the local voltage V_{CC} and the regulation voltage V_{REG}. In another embodiment, for example, the modulated frequency of the frequency modulation signal **1822** may be inversely proportional to the potential difference between the local voltage V_{CC} and the regulation voltage V_{REG}. In any event, the feedback signal as discussed in FIG. **13** may include the frequency modulation signal **1822**.

The frequency modulation signal **1822** may be used for turning on and off the switch **1840**. According to the modulated frequency of the frequency modulation signal **1822**, the impedance component **1844** may be periodically connected to and disconnected from the DC input voltage (V_{IN}) node. The impedance component **1844** may act as an additional load and in the form of a pull down device. Because additional switching current I_Z is sunk by the impedance component **1844**, the DC input voltage V_{IN} may drop and rise at the modulated frequency of the frequency modulation signal **1822**.

As a result, the profile of the DC input voltage V_{IN} may be superimposed by the profile of the frequency modulation signal **1822**. The superimposed V_{IN} profile may become a modulated amplitude (e.g., the message envelop) of the passive telemetric signal **1357**. As a result, the switch **1840** may transform the frequency modulation signal **1822** to a frequency modulated amplitude modulated signal, such as the passive telemetric signal **1357**. The passive telemetric signal **1357** may be received and demodulated by the RF Board as part of the power regulation process.

Referring to FIG. **19**, various waveforms of the implant power regulation subsystem **1800** are shown according to an embodiment of the present invention. Initially, the voltage across the Zener diode **1862** (V_{ZENER}) may increase linearly and track the DC input voltage V_{IN} when the DC input voltage V_{IN} is less than the breakdown voltage V_{BD}. As such, the breakdown current I_{BD} may be kept at minimum and the regulation signal voltage level V_R may be close to ground.

Because the regulation signal voltage level V_R does not overcome the threshold voltage of the transistor **1876**, there may be minimum or no regulation current I_R flowing through the first and second pull down resistors **1874** and **1875**. As a result, the regulation voltage V_{REG} may track closely to the local voltage V_{CC}. Since V_{CC} may be set a voltage level (e.g. 5 V) lower than the breakdown voltage V_{BD} (e.g. 5.6 V), the regulation voltage VREG may be saturated before the regulation mechanism is triggered. At this stage, the impedance component **1844** may be decoupled from the V_{IN} node, such that only minimum or no switching current I_Z may be sunk from the V_{IN} node.

When the DC input voltage V_{IN} begins to exceed the breakdown voltage V_{BD}, the Zener diode **1862** may begin to conduct the breakdown current I_{BD}. As a result, the regulation signal voltage level V_R may begin to rise and it may eventually overcome the threshold voltage of the transistor **1876**. From the point when the transistor **1876** begins to conduct the regulation current I_R to the point when the transistor **1876** becomes saturated (i.e. maximum I_R), the power regulation subsystem **1800** may be under rapid regulation. That is, the regulation voltage V_{REG} may be highly sensitive to the slightest increase in the DC input voltage V_{IN}.

As the regulation current I_R increases, the regulation voltage V_{REG} may begin to decline, which may cause the frequency modulation device **1820** to generate the frequency modulation signal **1822**. Driven by the frequency modulation signal **1822**, the switch **1840** may cause the impedance component **1844** to be coupled to or decoupled from the V_{IN} node. Accordingly, the switching current I_Z may share the frequency of the frequency modulation signal **1840**. As discussed earlier, the frequency of the frequency modulation signal **1840** may be inversely proportional to the difference between the local voltage V_{CC} and the regulation voltage V_{REG}. Hence, the frequency of the frequency modulation signal **1840**, which may be represented by the profile of the switching current I_Z, may decrease as regulation voltage VREG drops further away from local voltage V_{CC}.

The discussion now turns to a double modulation scheme adopted by the Implant in providing feedback information to the RF Board. The feedback information may include the value of the regulation voltage V_{REG} and/or the patient's biometrics data. Generally, the Implant may include a memory device for storing the patient's biometrics data, such as the patient's identity and event records pertinent to the patient's gastric band adjustment history. Among other information, each of the event records may record the current gastric band position and the adjustment date. It is desirable that the Implant may telemetrically transmit various pieces of feedback information in a compact and efficient manner.

In FIG. **20**, waveforms of a double modulation (frequency modulated amplitude modulation) scheme are shown according to an embodiment of the present invention. Initially, there may be a data signal **2010** to be transmitted from the Implant to the RF Board. The data signal **2010** may have a high state **2012** and a low state **2014**, each of which may represent one of the binary states. For example, the data signal **2010** may have the high state **2012** during time period (TP) 1, the low state **2014** during TP 2, the high state **2012** during both TP 3 and TP 4, and the low state **2014** during TP 5.

Next, a frequency modulation may be applied to the digital signal **2010** to form a frequency modulation signal **2020**. Generally, the frequency modulation may be performed by the frequency modulation device **1820** or any other similar devices, such as a LTC6900 chip. The frequency modulation signal **2020** may have one or more modulated frequencies, such as a first (low) frequency **2022** and a second (high) frequency **2024**. Depending on the assignment scheme, the first and second frequencies **2022** and **2024** may be assigned to one of the low state **2012** or the high state **2024** of the data signal **2010**.

In the present case, for example, the first frequency **2022** may be assigned to the high state **2012**, and the second frequency **2024** may be assigned to the low state **2024**. Accordingly, the frequency modulation signal **2020** may have the first frequency **2022** during TP 1, the second frequency **2024** during TP 2, the first frequency **2022** during TP 3 and TP 4, and the second frequency **2022** during TP 5.

The frequency modulation signal **2020** may be used for encoding two or more signals simultaneously. In one embodiment, for example, the frequency modulation signal **2020** may be used for encoding two digital signals with four logic states. As such, the frequency modulation signal **2020** may have four frequency levels assigned to the four logic states. In another embodiment, for example, the frequency modulation signal **2020** may be used for encoding three digital signals with eight logic states. Accordingly, the frequency modulation signal **2020** may have eight frequency levels assigned to the eight logic states.

In yet another embodiment, for example, the frequency modulation signal **2020** may be used for encoding one digital signal and one analog signal. The digital signal may carry feedback information regarding the patient's biometrics. The analog signal may carry feedback information regarding the value of the regulation voltage V_{REG}. Accordingly, the frequency modulation signal **2020** may have a first frequency band and a second frequency band. Particularly, the high state of the digital signal and the spectrum of the analog signal may be jointly represented by the first frequency band, while the low state of the digital signal and the spectrum of the analog signal may be jointly represented by the second frequency band.

After the frequency modulation signal **2020** is generated, it may be combined, mixed, or superimposed with the original amplitude modulated carrier to form a frequency modulated amplitude modulation signal **2030**. The original amplitude modulated carrier may be originated from the RF Board, and it may retain its carrier frequency at the implant antenna. As such, the frequency modulated amplitude modulation signal **2030** may have a common carrier frequency and a message frequency. The common carrier frequency may be constant throughout the entire transmission period, while the message (envelop) frequency may track closely to the first and second frequencies **2022** and **2024** of the frequency modulation signal **2020**. Accordingly, the frequency modulated amplitude modulation signal **2030** may have a first message (envelop) frequency **2032** during TP 1, a second message (envelop) frequency **2034** during TP 2, and the first message frequency **2032** during TP 3.

Using the frequency modulated amplitude modulation signal **2030** to provide feedback information may provide several advantages. For example, the transmission of the frequency modulated amplitude modulation signal **2030** may consume very little energy from the Implant because it may take advantage of the original amplitude modulation signal and it may be passively transmitted. For another example, the intermediate frequency modulation scheme may allow multiple pieces of information to be transmitted simultaneously, thereby increasing the transmission efficiency and shortening the total transmission time. For another example, the frequency modulated amplitude modulation signal **2030** may only require one communication channel. As such, the external antenna and the implant antenna may be transferring power and communicating at the same time. For yet another example, the frequency modulated amplitude modulation signal **2030** may have a high tolerance to parasitic noise. Mainly, the underlying information may be encoded in different frequency levels and/or frequency bands, which may be highly resistive to distortion caused by parasitic noise.

FIG. **21** shows a schematic view of a double modulation subsystem **2100** according to an embodiment of the present invention. Generally, the double modulation subsystem **2100** may help generate the feedback signal for communicating the value of the regulation voltage V_{REG} to the RF Board. As such, the double modulation subsystem **2100** may be used as a communication system and in conjunction with the power regulation subsystem **1800**.

The double modulation subsystem **2100** may include a frequency modulation device **2120**, an output transistor **2150**, a data switch **2112**, a voltage regulation resistor R_{REG}, a data resistor R_{CMD}, and a bias resistor R_{BO}. The frequency modulation device **2120** may have similar functional features as the frequency modulation device **1820**. Moreover, the frequency modulation device **2120** may adjust a switching frequency (f_{SW}) of the frequency modulated signal **1822** according to the regulation voltage and the status of the data switch **2112**.

The data switch **2112** may be used for generating serial data signals similar to the data signal **2010** as shown in FIG. **20**. More specifically, the data switch **2112** may be controlled by the implant microcontroller **476** (previously shown in FIG. **4**), which may encode various information to the data signal.

In one embodiment, for example, the implant microcontroller may encode the patient's identification information to the data signal. In another embodiment, for example, the implant microcontroller may encode the patient's gastric band adjustment record to the data signal. In yet another embodiment, for example, the implant microcontroller may encode a handshake confirmation message to the data signal.

The frequency modulation device **2120** may be implemented by a LTC 6900 chip or other equivalent devices. From a functional standpoint, the frequency modulation device **2120** may determine the switching frequency according to the local voltage V_{CC}, a set voltage V_{SET} and an input current I_{RES}. Similar to the power system as shown in FIG. **18**, the regulation voltage V_{REG} may be generated by the regulation device **1370** at a first node (e.g., the V_{REG} node). The set voltage V_{SET} at a second node (e.g., the V_{SET} node) may be controlled by a data path, which may include the data switch **2112** and the command resistor R_{CMD}. Moreover, the voltage regulator **1872** may generate the local voltage V_{CC} at a third node (e.g., the V_{CC} node). The local voltage V_{CC} may perform as a current source for the pull up resistor **1874** and the data path.

In one embodiment, the frequency modulation device **2120** may include a differential amplifier **2132**, a pass transistor **2134**, and an oscillator **2140**. The differential amplifier **2132** may generate an input differential voltage V_{DIFF} by amplifying the potential difference between the local voltage V_{CC} and a set voltage V_{SET} (i.e. $V_{CC}-V_{SET}$). The pass transistor **2134** may be biased by a bias voltage V_{BIAS} to pass the input current I_{RES} from the V_{SET} node to the oscillator **2140**. After receiving the input differential voltage V_{DIFF} and the input current I_{RES}, the oscillator **2140** may generate the frequency modulation signal **1822** with the switching frequency f_{SW}, which may be modeled by Equation 1:

$$f_{SW} = 1\text{ MHz} \times 20\text{ k}\Omega \times \frac{I_{RES}}{(V_{CC} - V_{SET})}.$$

Generally, the input current I_{RES} may be a summation of several currents joining at the V_{SET} node. For example, when the data switch **2112** is closed, it may conduct a data current (I_{CMD}) from the V_{CC} node to the V_{SET} node. The data current I_{CMD} may be characterized as $(V_{CC}-V_{SET})/R_{CMD}$. For another example, a regulation current I_{REG} may be conducted across the regulation resistor R_{REG}. The magnitude of the regulation current I_{REG} may depend on the level of regulation, such that it may range from $(V_{CC}-V_{SET})/R_{REG}$ to about $0.5^*(V_{CC}-V_{SET})/R_{REG}$. For yet another example, a bias current I_{BO} may be conducted across the bias resistor R_{BO}, and it may be characterized as $(V_{CC}-V_{SET})/R_{BO}$.

When the data signal is at a low state (i.e. data switch **2112** closed) and when there is no power regulation, the switching frequency may be modeled by Equation 2, which recites:

$$f_{SW,LL,NR} = 1\text{ MHz} \times 20\text{ k}\Omega \times \left(\frac{1}{R_{BO}} + \frac{1}{R_{REG}} + \frac{1}{R_{CMD}}\right).$$

When the data signal is at a high state (i.e. data switch **2112** open) and when there is no power regulation, the switching frequency may be modeled by Equation 3, which recites:

$$f_{SW,HL,NR} = 1\text{ MHz} \times 20\text{ k}\Omega \times \left(\frac{1}{R_{BO}} + \frac{1}{R_{REG}}\right).$$

When the data signal is at a low state and when there is maximum power regulation, the switching frequency may be modeled by Equation 4, which recites:

$$f_{SW,LL,MR} = f_{SW,LL,NR} - 1\text{ MHz} \times 10\text{ k}\Omega \times \left(\frac{V_{CC}}{R_{REG} \times (V_{CC} - V_{SET})}\right).$$

When the data signal is at a high state and when there is maximum power regulation, the switching frequency may be modeled by Equation 5, which recites:

$$f_{SW,LL,MR} = f_{SW,HL,NR} - 1\text{ MHz} \times 10\text{ k}\Omega \times \left(\frac{V_{CC}}{R_{REG} \times (V_{CC} - V_{SET})}\right).$$

When the data signal is at a low state and when the regulation voltage is at V_{REG}, the switching frequency may be modeled by Equation 6, which recites:

$$f_{SW,LL,VR} = f_{SW,LL,NR} - 1\text{ MHz} \times 20\text{ k}\Omega \times \left(\frac{V_{CC} - V_{REG}}{R_{REG} \times (V_{CC} - V_{SET})}\right).$$

For low output level and regulation voltage at V_{REG}, the switching frequency may be modeled by Equation 7, which recites:

$$f_{SW,HL,VR} = f_{SW,HL,NR} - 1\text{ MHz} \times 20\text{ k}\Omega \times \left(\frac{V_{CC} - V_{REG}}{R_{REG} \times (V_{CC} - V_{SET})}\right).$$

As persons skilled in the art may readily appreciate, the value of the swing frequency f_{SW} may depend on the resistances of the various resistors, which may be adjusted to meet various design goals. In one embodiment, for example, the resistance of the bias resistor R_{BO} may be about 29.43 kΩ. In another embodiment, for example, the resistance of the regulation resistor R_{REG} may be about 1 MO. In yet another embodiment, for example, the resist R_{CMD} may be about 430 kΩ. Moreover, V_{CC} may be set at about 5V, such that V_{SET} may be at about 3.9V.

Accordingly, the swing frequency $f_{SW,LL,NR}$ may be about 746 kHz, the swing frequency $f_{SW,HL,NR}$ may be about 699.5 kHz, the swing frequency $f_{SW,LL,MR}$ may be about 700.5 kHz, and the swing frequency $f_{SW,HL,MR}$ may be about 654 kHz. Furthermore, the swing frequency $f_{SW,LL,VR}$ may range from about 746 kHz to about 700.5 kHz, while the swing frequency $f_{SW,HL,VR}$ may range from about 699.5 kHz to about 654 kHz.

Referring to FIG. **22**, a frequency chart of the double modulation scheme is shown according to the above parameters. With a binary data signal, the double modulation scheme may include a low state band **2202** and a high state band **2204**. The low state band **2202** may represent the range of swing frequencies that may be assigned to the low state value of the data signal. Similarly, the high state band **2204** may represent the range of swing frequencies that may be assigned to the high state value of the data signal. Because the swing frequency may incorporate or embedded with power regulation information, each of the low and high state bands **2202** and **2204** may have a maximum swing frequency (i.e. $f_{SW,LL,NR}$ and $f_{SW,HL,NR}$) for representing a no-regulation scenario, a transient swing frequency (i.e. $f_{SW,LL,VR}$ and $f_{SW,HL,VR}$) for representing a rapid regulation scenario, and a minimum swing frequency (i.e. $f_{SW,LL,MR}$ and $f_{SW,HL,NR}$) for representing a maximum-regulation scenario.

Although FIG. **22** shows only two swing frequency bands, the frequency modulation device **2100** may provide two or more swing frequency bands. In one embodiment, for example, the frequency modulation device **2100** may provide four swing frequency bands for encoding two binary data signals. In another embodiment, for example, the frequency modulation device **2100** may provide eight swing frequency bands for encoding three binary data signals. In yet another embodiment, for example, the frequency modulation device **2100** may provide sixteen swing frequency bands for encoding four binary data signals.

The discussion now turns to the demodulation scheme and the demodulation device used for decoding the feedback signals from the Implant. FIG. **23**A shows a frequency spectrum of the frequency modulation feedback signal according to an embodiment of the present invention. Generally, the frequency modulation feedback signal may occupy one of the low state band **2202** or the high state band **2204** to transmit a single binary bit of data. However, the frequency modulation feedback signal may shift from a higher end of the band to a lower end of the band as the regulation voltage V_{REG} of the implant increases. Such intra-band frequency shift may occur during the transmission of the single binary bit of data. Advantageously, the RF Board may be able to regulate the power within the Implant in real time, so that the regulation process may be independent of the data transmission process.

FIG. **23**B shows a demodulation **2300** of the frequency modulated amplitude modulation signal according to an embodiment of the present invention. Generally, the demodulation signal may map a low frequency band to a high voltage state, and it may map a high frequency band to a low voltage state. Moreover, the demodulation signal may have a first DC level **2310** when the implant requests no regulation, and it may have a second DC level **2330** when the Implant requests power reduction (or power regulation). Accordingly, a potential difference **2320** between the first and second DC levels **2310** and **2320** may correspond to the level of power reduction requested by the Implant.

FIG. **23**B shows that the maximum regulation demodulation signal may overlap with the no regulation demodulation signal. However, in an alternative embodiment, the maximum regulation demodulation signal and the no regulation demodulation signal may occupy non-overlapping voltage ranges.

Referring to FIG. **24**, a schematic view of a demodulation device **2400** is shown according to an embodiment of the present invention. Generally, the demodulation device **2400** may implement the functional features of the demodulation device **1330** as discussed in FIG. **13**. Particularly, the demodulation device **2400** may include a demodulation processor **2410**, a low pass filter **2420**, a signal strength amplifying stage **2422**, a data amplifying stage **2432**, a three-stage power control amplifying stage **2440**, and a power override device **2450**.

The demodulation processor **2410** may be used for processing the signal ANT_RX, which may be received and extracted from the external antenna. The signal strength amplifying stage **2422** may receive the processed signal and generate a signal strength indicator signal RSSI. Generally, the signal strength indicator signal RSSI may indicate the strength of the telemetric coupling between the external antenna and the implant antenna.

The low pass filter **2420** may be used for filtering out the high frequency component of the processed signal. As such, the carrier frequency may be eliminated, and the frequency modulated feedback signal may be further processed. Next, the data amplifying stage **2432** may receive the filtered signal and generate a data signal RF_RX according to the state band of the filtered signal. Simultaneously, the three-stage power control amplifying stage **2440** may receive the filtered signal and generate a voltage supply control signal VSUP_CTRL according to the frequency shift caused by the regulation voltage VREG.

Accordingly, the power supply device **1340** (previously shown in FIG. **13**) may use the voltage supply control signal VSUP_CTRL to adjust the RF supply voltage **1342**. Because the modulation device **1320** may be powered by the RF supply voltage **1342**, the amplitude component of the amplitude modulation signal may be controlled indirectly by the RF supply voltage **1342**. As a result, the power transmission may be regulated by reducing the amplitude component of the amplitude modulation signal.

Additionally, the three-stage power control amplifying stage may include a second stage **2444** for generating a regulation level signal REG_LEVEL, which may indicate the level of regulation requested by the Implant. Generally, the level of regulation may be higher when the Implant's DC input voltage VIN is much higher than the breakdown voltage VBD. Alternatively, the level of regulation may be lower when the Implant's DC input voltage VIN is below or slightly above the breakdown voltage VBD.

FIG. **25** shows the relationship among various output signals of the demodulation device and a transmission distance separating the external antenna and the implant antenna. Generally, as the transmission distance increases, the signal strength indicator signal RSSI and the regulation level signal REG_LEVEL may increase. As such, the RF voltage supply VSUP may decrease to reduce the power transmission to the Implant. As shown in FIG. **25**, the RF Board and the Implant may undergo rapid power regulation when the transmission distance ranges from 30 mm to about 40 mm. Moreover, the RF Board and the Implant may undergo maximum power regulation when the transmission distance is below 20 mm.

According to an embodiment of the present invention and referring again to FIG. **11**, the FM demodulator in the RF demodulator block **1108** may generate a received signal strength indicator (RSSI), a REG_LEVEL signal and a VSUP_CTRL signal. Ultimately the VSUP_CTRL signal controls the output voltage VSUP. FIG. **25** shows some exemplary results of the RSSI signal, the REG_LEVEL signal, and the output voltage VSUP at various transmission distances.

The discussion now turns to the software algorithms implemented in the HID subsystem and the RF subsystem. FIG. **26** shows the communication protocol UART **2600** among the HID subsystem, RF subsystem, and the implant according to an embodiment of the present invention. Generally, the HID microcontroller **2622** may function as the master device within the control device (control unit) **2620** and it may control most user interfaces, such as the display device, the buttons, the audio output device (e.g., speaker), and the memory devices. The HID microcontroller **2622** may send command message **2602** to the RF microcontroller **2624**, and request the RF microcontroller **2624** to perform several functions.

The RF microcontroller **2624** may perform as a slave to the HID microcontroller **2622**. Nevertheless, the RF microcontroller **2624** may send notification messages **2604** to the HID microcontroller **2622** even without being requested. The RF microcontroller **2626** may control the power induction process in the implant, the charging circuit in the docking station, the communication to and from the implant, and the communication with the HID microcontroller **2622**. The GND-GND link **2608** may provide the "0 Volt" reference for all other signals. The RTS-CTS link **2606** may be a flux control line, which may be used for stopping the incoming flux of data from the HID sub-system when the RF sub-system is not ready to accept them.

FIG. **27** shows the state diagram of the HID subsystem algorithm **2700** according to an embodiment of the present invention. Each state and transition will be discussed in detail in conjunction with FIGS. **8**A-**8**R, which shows various screen shots of the control device. Generally, there may be five major blocks of states, including the power off block **2710**, the active or power on block **2720**, the charge block **2750**, the error block **2760**, and the warning block **2770**.

The transition from the power off block **2710** to the power on block **2720** may be triggered by pressing the power on button on the control device **110** as shown in FIGS. **5**A and **5**B. Similarly, the transition from the power on block **2720** to the power off block **2710** may be triggered by pressing the power off button or after a 10-minute time out delay since a user has not interacted with the HID subsystem.

Generally, any state within the power on block **2720** may transit to the warning block **2770** and/or the error block **2760**. To exit the warning block **2770** and/or the error block **2760**, the user may enter the power off block **2710** by pressing the power off button or waiting for the 10-minute time out delay.

The charge block **2750** may be entered when the control device is connected to the docking station during the active mode. Once the control device is disconnected from the docking station, the charge block **2750** may return to a previous state of the power on block **2720**. Normally, the returned state may be a state from which the charge block **2750** is transited initially.

As the power on block **2720** is initiated, the INIT state **2722** may initialize the HID subsystem, display the welcome screen, and load the code entry screen. After that, the ASKING FOR CODE state **2724** may be entered. The ASKING FOR CODE state **2724** may repeat itself until a correct 4-digit pass code is received, upon which the SEARCHING state **2726** may be entered. Once the external antenna is positioned close enough to the implant to establish a sufficient good telemetric (or electromagnetic) coupling, which may be represented by three out of five search bars in the searching screen, the UPLOADING state **2728** may be initiated.

In the UPLOADING state **2728**, the loading start screen may be displayed, followed by the loading end screen. Moreover, the implant is powered up and the communication with the implant is initiated. If, at any point of the UPLOADING state **2728**, the telemetric coupling deteriorates and becomes insufficient, the HID subsystem may return to the SEARCHING state **2726**. Otherwise, the patient information is uploaded from the implant such that the STANDBY state **2730** may be initiated.

The STANDBY state **2730** may lead to several states depending on the triggering conditions. For example, if the magnetic coupling deteriorates and becomes insufficient, the HID subsystem may return to the SEARCHING state **2726**. For another example, if the Locked key is pressed, the HID subsystem may enter the LOCKED state **2732** in which the locked screen may be displayed, and from which any key may be pressed to return to the ASKING FOR CODE state **2724**.

For yet another example, if the code-change auxiliary key is pressed, the HID subsystem may enter the ASKING FOR OLD CODE state **2734** in which the enter-old-code screen may be displayed. Once the correct 4-digit code is received and the Next auxiliary key is pressed, the ASKING FOR NEW CODE state **2736** may be entered, in which the enter-new-code screen may be displayed. After receiving the new 4-digit code, the HID subsystem may enter the CONFIRM NEW CODE state **2738**, in which the confirm-or-cancel-code screen may be displayed and the user may elect to either confirm or cancel the entered code. If the user presses the OK auxiliary key to confirm the entered code, the code changed screen may be displayed and the HID subsystem may return to the STANDBY state **2730**; otherwise, if the user presses the Cancel auxiliary key to cancel the entered new code, the HID subsystem may simply return to the STANDBY state **2730**.

While in the STANDBY state **2730**, the user may request a graph of the patient's gastric band adjustment history by pressing the Chart auxiliary key. Accordingly, the GRAPH state **2740** may be entered, and the history plot screen may be displayed. From the GRAPH state **2740**, the HID subsystem may enter the LIST state **2742** if the user presses the List auxiliary key, thereby loading the history list screen. After reviewing the history plot screen and/or the history list screen, the user may press the Return key to return to the STANDBY state **2730**.

Moreover, the user may adjust the width of the gastric band from the STANDBY state **2730**. For example, when the Open button is pressed, the HID subsystem may enter the MOVE IMPLANT state **2744**, in which the opening screen may be displayed. Accordingly, the implant motor may drive the gastric band to expand its diameter. For another example, when the Close button is pressed, the HID subsystem may initiate the MOVE IMPLANT state **2744**, in which the closing screen may be displayed. Accordingly, the implant motor may drive the gastric band to constrict its diameter.

In order to achieve a desirable gastric band diameter, the user may repeat the above process either by pressing the Open button or Close button repeatedly, or by pressing the Open button and the Close button alternately. During the MOVE IMPLANT state **2744**, if the implant motor is blocked and such blockage is detected, the HID subsystem may return to the STANDBY state **2730**. Moreover, during the MOVE IMPLANT state **2744**, if the magnetic coupling deteriorates and becomes insufficient, the HID subsystem may return to the SEARCHING state **2726**.

When the control device is connected to the docking station, the CHARGE block **2750** may be entered, during which the battery recharging may be performed and the battery recharging screen may be displayed. In the CHARGE block **2750**, the initial state is the FAST CHARGE state **2752**, during which the recharging process is controlled by current. Once the fast charging is complete, the NORMAL CHARGE state **2754** may be entered, and the battery recharging process may be controlled by voltage. Once the battery is fully charged, the HID subsystem may enter the FULL CHARGE state **2756**. The HID subsystem may alternate between the NORMAL CHARGE state **2754** and the FULL CHARGE state **2756** if the control device remained connected to the docking station long enough for the battery to dissipate some of the charges.

The discussion now turns to the RF subsystem algorithm. FIG. **28** shows the state diagram of an RF subsystem algorithm **2800** according to an embodiment of the present invention. The RF subsystem powers and communicates with the implant, such that it may manage the implant's telemetric (electromagnetic) coupling, control the implant's power consumption, count the motor steps, and receive feedback information from the implant. The RF subsystem may also communicate with the HID subsystem, monitor battery recharging, respond errors and interrupts, and perform cyclic redundant check (CRC), delay, filtering and driving.

As shown in FIG. **28**, the RF module cycles among four different states, each of them may last about 500 μs. The first state may be the HID Communication state **2810**, in which the RF subsystem may receive up to two commands from the HID subsystem. In response, the RF subsystem may respond to these commands by sending up to eight notification messages. The second state may be the RF Power state **2820**, in which the power level to the implant may be monitored and controlled. The third state may be the Implant Communication state **2830**, in which data may be sent to and/or received from the implant. The received data may be further analyzed in this state. The fourth state may be the Battery Charger state **2840**, in which battery power may be monitored and controlled if the control device (control device) is properly connected to the docking station. Generally, the RF subsystem may cycle or return back to the HID Communication state **2810** after completing the Battery Charger state **2840**.

Referring again to FIG. **26**, the HID microcontroller **2622** may interact with the RF microcontroller **2624** through a UART interface **2600**. Generally, the HID microcontroller **2622** (master) may send up to two commands consecutively. The HID microcontroller **2622** (master) may demand answer messages from the RF microcontroller **2624** (slave). In response, the slave may send up to eight notifications consecutively to the master. According to an embodiment of the present invention, Table 2 below shows the data structures for the command, the answer message and the notification message.

TABLE 2

Data structures of the command message, the answer message, and the notification message.

HEADER			DATA			CRC
					DATA	CRC
CODE	SEQ	LENGTH	DATA[0]	. . .	[Length − 1]	CRC
COMMAND FROM MASTER (HID)						
16-bit	16-bit	16-bit	16-bit	. . .	16-bit	16-bit
ANSWER MESSAGE FROM SLAVE (RF)						
0x0000	16-bit	16-bit	16-bit	. . .	16-bit	16-bit
NOTIFICATION MESSAGE FROM SLAVE (RF)						
0x4154	16-bit	16-bit	16-bit	. . .	16-bit	16-bit

These command and messages may share a similar data structure, which may includes a six-byte header followed by a 2*LENGTH-byte long data field and a two-byte CRC code. As discussed herein, LENGTH may be a predefined parameter specifying the length of the data. Within the six-byte header, the first two bytes contain the command code, the next two bytes contain a sequence number, and the last two bytes describe the LENGTH of the following data field. The data field may be empty if LENGTH equals 0.

Generally, the HID master does not transmit all the header bytes at one time. In one embodiment, for example, FIG. **29**A shows a command only communication protocol between the HID and RF subsystems. More particularly, the HID master may send a two-byte command code to the RF slave, which may respond by sending back an ACK message. Upon receiving the ACK message, the HID master may begin transmitting the Sequence bytes, the LENGTH bytes, and the CRC bytes according to the shown order.

In another embodiment, for example, FIG. **29**B shows a command-data communication protocol between the HID and RF subsystems. The protocol illustrated in FIG. **29**B may be similar to the protocol illustrated in FIG. **29**A except that the Data bytes may be sent after the LENGTH bytes.

Next, FIG. **30** shows an answer message communication protocol from the RF subsystem according to an embodiment of the present invention. After receiving and processing the command message from the HID master, the RF slave may send back an answer message with data structure as shown in Table 2. Similarly, FIG. **31** shows that the RF slave may initiate notification message without receiving prior command from the HID master.

The discussion now turns to the features of the docking station. FIGS. **32**A-**32**C show an exploded view, a front view and a back view of a docking station **3200** according to an embodiment of the present invention. Generally, the docking station **3200** may include a bottom shell **3202**, a top shell **3204**, four rubber foot **3206**, a regulatory sticker **3208**, a ballast 2 bottom **3210**, a ballast 1 top **3212**, a magnet **3214**, two alignment pins **3216**, a main PCB **3218**, and a supplementary PCB **3220**.

The docking station **3200** may have a saddle structure **3232**, which may provide one or more contact point for coupling with the control device. The main PCB **3218** may be used for performing power protection to protect the docking station **3200** and the control device from the power surge of the power adapter. Moreover, the main PCB **3218** may assist the RF subsystem in monitoring the charging status and the charging temperature.

FIG. **33** shows a schematic view of the docking station subsystem **3310** interacting with the RF Board **3350** according to an embodiment of the present invention. The docking station system **3310** may be implemented by the main PCB **3218** (see FIG. **32**), and it may include a temperature measurement block **3312**, a power supply management block **3314**, a protection block **3316**, and a shunt resistance device **3318**. The power supply management block **3314** may interact with the RF board **3350** to perform battery charging (charging status) management and charging temperature (overheat prevention) management.

Charging current may be estimated by measuring voltage across the shunt resistance device **3318**. In one embodiment, for example, the shunt resistance device **3318** may have a resistance of about 0.015Ω. Moreover, there may be NTC thermistors inside the batteries for proper temperature measurement, as well as several polyswitches for resetting the circuit in case of power surges at the battery level.

FIG. **34** shows a fast charge mode voltage-current chart according to an embodiment of the present invention. At the beginning of the fast charge mode, the charging process is controlled through a constant current I_{ch}. According to an embodiment of the current invention, I_{ch} may be about 5 A. After the battery charge V_B reaches a certain voltage, it will decrease by ΔV and the charging circuit then switches to the normal charge mode.

The RF board may perform the charge monitoring. A dedicated NiMh charger chip (e.g., the LTC1759 chip) may be used for controlling the charging process. The LTC1759 chip may use temperature measurement of the battery pack to adjust its charging algorithm. The LTC1759 chip may be a high current DC-to-DC power supply controlled by a NiMH charger controller, both of which may be included in a single chip. Thus, the LTC1759 chip may control the power given to the battery pack and ensure that it complies with the charging profile as shown in FIG. **34**.

The discussion now turns to the retractable external antenna (external antenna with retractable cable). FIGS. **35**A-**35**B show a perspective view and an exploded view of an external antenna with retractable cable according to an embodiment of the present invention. Generally, the retractable external antenna **3500** may include an antenna bottom **3502**, an antenna top **3504**, a winding drum **3506**, a gear wheel **3508**, a button **3510**, a button ring **3512**, a metal plate **3514**, a PCB **3516**, a tap **3518**, a compression spring **3522**, a drive spring **3524**, an antenna cable **3526**, a gear wheel pin **3528**, a center axis **3530**, a winding drum lid **3532**, a sound barrier **3534**, a glide plate **3536**, and a ball bearing **3538**.

To achieve smooth retraction, the retractor components are placed inside of the winding drum **3506** while the antenna cable **3526** retracts on the circumferential surface of the winding drum **3506**. In order to enable proper power induction, the cable of the antenna may be fully deployed until a green marker can be seen. Otherwise, the coiled antenna cable may absorb excessive power induction energy. The retractable external antenna can be attached to the control device by pushing the connector against the control device until a "click" is heard, which signifies that the antenna cable **3626** is locked. Once locked, the antenna cable **3626** is in a suitable configuration. The locking mechanism ensures a good electromagnetic coupling by establishing a unique and stable resting position for the cable.

The gear wheel **3508** may include a small spring loaded pin (gear wheel pin) **3528**. The antenna top **3504** may have a small hole (not shown). The "click" sound may be produced when the spring loaded pin **3528** enters into the small hole. This may occur when the spring loaded pin **3528** is in front of the hole after the antenna cable **3526** is fully unwound. When the bottom ring **3512** is pressed, the spring loaded pin **3528** may be disengaged, thereby releasing the antenna cable **3526**.

As shown in FIGS. **36**A and **36**B, the retractable external antenna **3500** may be stored at the back of the control device according to an embodiment of the present invention. The magnetic pins **3606** of the control device provide easy connection points for connecting to the docking station.

The discussion now turns to various structural and functional features of the implant. Referring to FIGS. **37**A-**37**B, a perspective view and an exploded view of the implant **3700** (e.g., a gastric band system) are shown according to an embodiment of the present invention. Generally, the implant **3700** may include a membrane shell **3702**, a dorsal element **3704**, a motor sleeve **3706**, an implant electronic device enclosure (protection case) base and cable sleeve **3708**, a manipulation handle **3710**, a cable sleeve **3712**, a skeleton **3714**, an implant electronic device enclosure (protection case) cover **3716**, a motor and cable assembly **3718**, a flexible screw assembly **3720**, an implant electronic device PCB **3722**, and a stabilizing tube **3724**.

The dorsal element **3704** may have a first end, a second end, and a curvy semi-tubular body connecting the first and second ends. The first end of the dorsal element **3704** may have a flange lock and a first opening, while the second end of the dorsal element **3704** may have an open compartment.

Similarly, the skeleton **3714** may have a distal end, a proximal end, and a ladder body connecting the distal end and the proximal end. The proximal end of the skeleton **3714** may have an open compartment for receiving the motor assembly **3718**. Initially, the distal end of the skeleton **3714** may slide into the second end of the dorsal element **3704**, along its semi-tubular body, and stop at the first end of the dorsal element **3704**. The distal end of the skeleton **3714** may be secured to the first end of the dorsal element **3704**, while the open compartment of the skeleton **3714** may fit into the open compartment of the dorsal element **3704**. In such manner, the ladder body of the skeleton **3714** may push against the inner surface of the semi-tubular body of the dorsal element **3704**. Accordingly, the skeleton **3714** may provide support to the semi-tubular body of the dorsal element.

The stabilizing tube **3724** may be inserted into the ladder body of the skeleton **3714**, such that it may be used for filling in the space defined by the ladder body and for stabilizing the ladder structure.

The motor assembly **3718** may have a motor coupled to a motor cable. The motor may be arranged to receive and maneuver the flexible screw assembly **3720**. For example, the motor may have one or more set of rotors and/or gears for engaging a threaded section of the flexible screw assembly **3720**. The motor may move a crimped end of the flexible screw assembly **3720** towards or away from the motor.

The flexible screw assembly **3720** may have a hooked end, which may be guided through a center conduit (space) of the stabilizing tube **3724**. Because the stabilizing tube **3724** is adapted to the curvy shape of the dorsal element **3704**, the flexible screw assembly **3720** may be bended with the stabilizing tube **3724**. After leaving the stabilizing tube **3724**, the hook end of the flexible screw assembly **3720** may be secured to the distal end of the skeleton, which may be secured to the first end of the dorsal element.

Next, the motor of the motor assembly **3718** may engage the flexible screw assembly **3720**. The flexible screw assembly may have an inner section that is inserted into the stabilizing tube **3724**. Also, the flexible screw assembly **3720** may have an outer section that stays outside of the stabilizing tube **3724** and extends beyond the open compartments of the skeleton **3714** and of the dorsal element **3704**. The motor of the motor assembly **3718** may then engage the threaded section of the flexible screw assembly **3720**, and move the crimped end of the flexible screw assembly **3720** away from the motor.

The membrane shell **3102** may have a tubular body, which may be used for covering the semi-tubular body of the dorsal element **3704**. The cable sleeve **3712** may be used for covering and protecting the motor cable, and the motor sleeve **3706** may be used for covering and protecting the motor.

The open end of the motor cable may be soldered onto the implant electronic device PCB **3722**, which may be protected by the enclosure cover **3716** and the enclosure base **3708**. The flange of the manipulation handle **3710** may be inserted through the hole of the implant electronic device enclosure, folded over, and secured to the implant electronic device enclosure by applying an appropriate amount of MED2-4213 silicon glue or the equivalent thereof on the flange and the cavity of the manipulation handle **3710**. The tapered end of the manipulation handle may be inserted and guided through the opening located at the first end of the dorsal element **3704**, thereby leading the second end of the dorsal element **3704** to be inserted into the first end of the dorsal element **3704**.

Consequently, the dorsal element **3704**, and the membrane shell **3702**, may form a ring structure. Particularly, the ring structure may have an adjustable ventral (inner) ring surface and a rigid dorsal (outer) ring surface. The adjustable ventral ring surface may be equipped with several cushion members for applying pressure against the stomach of a patient.

As persons skilled in the art may readily appreciate, an appropriate amount of MED2-4213 silicon glue, or the equivalence thereof, may be applied to various components, and the various junctions of thereof, of the implant **3700** for strengthening the overall structure of the implant **3700**.

The discussion now turns to the implant electronic device protection case (enclosure) components. Generally, the implant electronic device PCB **3722** may be coupled to the motor cable, such that the implant electronic device PCB **3722** may send control signals to the motor and sense a motor coil current of the motor. The implant electronic device PCB

3722, and the junction at which the implant electronic device is coupled to the motor cable, may be protected by the implant electronic device enclosure, which may include the enclosure cover 3716, the enclosure base 3708, and the strain relieving sheath 3850.

FIGS. 38A and 38B shows a top perspective view and a bottom perspective view of an enclosure base shell 3810 according to an embodiment of the present invention. Generally, the enclosure base shell 3810 may be part of the enclosure base 3708. Particularly, the enclosure base shell 3810 may include a compartment 3814 for fitting the electronic device PCB 3722, a cable port 3812 for receiving and guiding the motor cable, and a handle hinge 3816 for receiving the flange of the manipulation handle 3710.

Referring to FIG. 38C, a perspective view of a cladding 3820 is shown according to an embodiment of the present invention. Generally, the cladding 3820 may be part of the enclosure cover 3716. Particularly, the cladding 3820 may be coupled to and cooperate with the enclosure base shell 3810 for guiding and protecting the motor cable. The cladding 3820 may include a plurality of openings to allow silicon material to be overmolded therein.

Referring to FIG. 38D, a perspective view of an enclosure cover shell 3830 is shown according to an embodiment of the present invention. Generally, the enclosure cover shell 3830 may be part of the enclosure cover 3716. The enclosure cover shell 3830 may be detachably coupled to the enclosure base shell 3810 and the cladding 3820 to form the enclosure case. The enclosure case may provide stability and protection for the implant electronic device PCB 3722 and for the connection established between the implant electronic device PCB 3722 and the motor cable.

Referring to FIG. 38E, the strain relieving sheath 3850 may be used for providing flexible support for the motor cable around the cable port 3812 area. The strain relieving sheath 3850 may help prevent breakage of the motor cable by restraining the motion of the motor cable around the cable port 3812 area. Referring to FIG. 38F, the extremity of the strain relieving sheath 3850 may have a silicone-PEEK overmolding and a plurality of internal bumps 3852 for keeping the cladding 3820 centered and for distributing the glue evenly.

The discussion now turns to the implant electronic device PCB 3722. FIGS. 39A-39B show a top view and a bottom view of an implant electronic system board (PCB) 3900, which may be used for implementing the functional features of the implant electronic device PCB 3722. Referring to FIG. 39A, the PCB 3900 may include a power regulation subsystem circuitry 3901, a microprocessor 3902, and an implant antenna 3904. The implant (internal) antenna 3904 may loop around the periphery of the PCB 3900, and it may be responsible for receiving the RF signals transmitted from the external antenna of the control device.

The power regulation subsystem circuitry 3904 may be coupled to the implant antenna 3904 via the L2 connection port 3906. The power regulation subsystem circuitry 3901 may include a power regulator 3908 for maintaining the local voltage V_{CC}. Moreover, the power regulation subsystem circuitry 3904 may receive the induced power and generate the power regulation signals when the DC input voltage V_{IN} is above certain predetermined threshold (e.g. 5.6 V).

The microprocessor 3902 may be coupled to the power regulation subsystem circuitry 3901. The microprocessor 3902 may be coupled with the implant antenna 3904. Generally, the microprocessor 3902 may be used for generating frequency modulation signals, which may be embedded with power regulation information and gastric band adjustment history information.

Particularly, the microprocessor 3902 may be used for receiving and processing commands send from the control device 110 as shown in FIG. 1. For example, the microprocessor 3902 may receive a gastric band adjustment command from the control device 110. In response, the microprocessor 3902 may send motor step signal to the motor for adjusting the width of the gastric band.

Moreover, the microprocessor 3902 may receive a gastric band adjustment history request command from the control device 110. In response, the microprocessor 3902 may retrieve the requested data from a memory device (not shown) and send the retrieved data back to the control device. In one embodiment, the microprocessor 3902 may have about 8 kB of programmable memory, 512 Bytes of data memory, 512 Bytes of SRAM, two timers, several input and out pins, one comparator, an A/D converter and several interrupt sources.

Referring to FIG. 39B, the bottom surface of the implant electronic system board 3900 may have nine oval connection pads 3912, each of which may be soldered to one of nine motor wires of the motor cable. Among the nine ovals connection pads 3912, eight of them may be grouped in four parallel pairs to provide redundancy protection. The remaining one oval connection pad 3912 may be soldered to an FC wire. The large metallic surface 3914 may be soldered to a motor cable center ground wire (GND).

The discussion now turns to the structural and functional features of the manipulation handle 3710. FIGS. 40A-40C show various views of a manipulation hand 4000, which may be used for implementing the functional features of the manipulation handle 3710. Generally, the manipulation hand 4000 may have a tapered end 4042, a base end 4044, an elongated body 4043 connecting the tapered end 4042 and the base end 4044, and a flange 4052 coupled to the base end 4044.

The flange 4052 may engage the handle hinge 3816 of the implant electronic device enclosure 3810. The profiled of the elongated body 4043 may allow easier insertion into the opening of the dorsal element. Specifically, the elongated body 4043 may have an increase thickness from the tapered end 4042 to the base end 4044. Moreover, the elongated body 4043 may have helicoidal arrows 4046, which may be used for indicating the direction for insertion. In one embodiment, the helicoidal arrows 4046 may form on one side of the elongated body 4043. In another embodiment, the helicoidal arrows 4046 may form on both sides of the elongated body 4043 as shown in FIG. 40C. Accordingly, the helicoidal arrows 4046 may be viewed at most angles during the implant procedure.

Referring to FIG. 40B, the manipulation handle 4000 may have first, second, third and fourth widths. In one embodiment, for example, the first width 4002 may be about 10.34 mm, the second width 4004 may be about 17 mm, the third width 4006 may be about 3.33 mm, and the fourth width 4008 may be about 4.2 mm.

Referring to FIG. 40C, the manipulation handle 4000 may have a flange length 4010 and a body length 4038. In one embodiment, for example, the flange length 4010 may be about 13.5 mm, and the body length 4038 may be about 100.3 mm. The flange 4052 may have a flange thickness 4012, which may be about 1.4 mm. The elongated body 4043 may have twelve thicknesses. In one embodiment, for example, the first thickness 4014 may be about 4.96 mm, the second thickness 4016 may be about 4.5 mm, the third thickness 4018 may be about 3.9 mm, the fourth thickness 4020 may be about

3.6 mm, the fifth thickness **4022** may be about 3.45 mm, the sixth thickness **4024** may be about 3.42 mm, the seven thickness **4026** may be about 3.4 mm, the eighth thickness **4028** may be about 3.2 mm, the ninth thickness **4030** may be about 3.03 mm, the tenth thickness **4032** may be about 2.9 mm, the eleventh thickness **4034** may be about 2.8 mm, and the twelfth thickness **4036** may be about 1.7 mm.

The discussion now turns to the software algorithm of the implant electronic system. In FIG. **41**, a state diagram of implant electronic device software algorithm is shown according to an embodiment of the present invention. Generally, the implant electronic device software algorithm may be executed by the microprocessor **3902** to perform various functions, such as driving the motor, counting the motor steps, detecting and eliminating motor blockage, storing and sending the patient's identification number and record information, such as the implantation date and the history of the last ten adjustments, and performing a self test on motor coils and other electronic components.

Upon receiving inductive power from the RF Board, the implant electronic system may enter the "Init" state **4100**, in which the microprocessors, the A/D converters, the input/output devices, interrupt devices, comparator, and watchdog devices may be initialized. Once the initialization is completed, the implant electronic system may enter the "Power On Self Test" state **4102**, in which the motor coils may be tested. If the self test is successful, the implant electronic system may enter the "Send ID" state **4108**. Otherwise, the implant electronic system may enter the "Error Detected" state **4104**, in which the RF transponder may notify the control device **110** with the appropriate message.

The "Send ID" state **4102** may be the default state, such that it may loop itself and continuously send ID messages back to the control device **110** until additional command is sent form the control device.

Referring to FIGS. **42**A and **42**B, the data structure of the ID messages may include three ID bytes, two status bytes, three motor position bytes, and one CRC code check byte.

Referring again to FIG. **41**, the implant electronic system may transit out of the "Send ID" state **4102** once it receives a command from the control device. For example, the implantation date will be recorded in the EEPROM in the "Record Date" state **4112** if a "record date" command is received and the implantation flag is False. For another example, the last 10 implant's positions will be sent back to the control device during the "Send History" state **4116** if a "send history" command is received.

Moreover, the implant electronic system may enter the "Adjust Band" state **4110** if an "Open" or "Close" command is received. During the "Adjust Band" state, the motor sequence may be activated, such that the motor may be directed to rotate clockwise or counter-clockwise.

A complete list of commands and the associating transmission protocol can be found on FIGS. **43**B and **44**B. Particularly, FIG. **43**B illustrates the data structure of commands that do not require additional parameters being sent to the implant, whereas FIG. **44**B illustrates the data structure of commands that require additional parameter.

Among the no-parameter commands, the "ImplantRequestStopPower" command may instruct the implant to stop powering the motor; the "ImplantRequestSelfTest" command may request the implant to perform a self test procedure; the "ImplantGetCurrentDate" command may request the implant to get the current date; the "ImplantGetSerialNumber" may instruct the implant to get the serial number; the "ImplantGetFirmwareVersion" may instruct the implant to get the firmware version; the "ImplantGetStepCounter" command may instruct the implant to gets the current motor step counter; the "ImplantEepromRecovery" command may instruct the implant to recover all stored EEPROM memory; and the "ImplantGetExtendedStatusRegister" command may instruct the implant to get value of an extended status register.

Among the with-parameter commands, the "ImplantOpenNStep" command may ask the implant to turn the stepper motor clockwise by a number of steps in order to open the band; the "ImplantCloseNStep" command may ask the implant to turn the stepper motor counter-clockwise by N number of steps in order to close the band; the "ImplantWriteByteEeprom" command may instruct the implant to write a byte of data into the EEPROM; the "ImplantSetCurrentDate" command may instruct the implant to set and store the current date; the "ImplantReadHistory" command may instruct the implant to read the adjustment history; the "ImplantGetParameters" command may instruct the implant to get some specific parameters; and the "ImplantReadEepromRecovery" may instruct the implant to recover a specific record stored in EEPROM.

Referring again to FIG. **41**, motor coil currents may be monitored during the motor sequence initialization and throughout the motor rotation phase for detecting and eliminating motor blockage. If a motor blockage is detected, the implant electronic system may enter the "Unblock Motor" state **4106** to resolve the motor blockage issue. In one embodiment, the motor may be directed to reduce its rotation speed, so that it may generate more torque to overcome the motor blockage. In another embodiment, the motor may be directed to change the rotation direction if the motor speed reduction scheme fails to remove the motor blockage.

If these two schemes do not resolve the motor blockage issue, the implant electronic system may enter the "Error Detected" state **4104**, in which an error message will be sent to the control device **110**.

Otherwise, the implant electronic system may return to the "Adjust Band" state **4110** to continue adjusting the gastric band. When the adjustment is completed, the implant electronic system may enter the "Record Implant Position" state **4118**, in which the last adjustment and the received date will be recorded in the EEPROM.

The discussion now turns to the communication protocol between the control device and the implant electronic system. FIG. **49** shows a timing diagram of a computer interrupt sequence upon a detection of a control device command at the implant. The command **4904** may be sent by the control device, and it may be carried by an amplitude modulation signal at a carrier frequency of about 27 MHz. Once the command **4904** is separated from the carrier, it may be fed to a comparator to generate the interrupt sequence **4902**. Referring to the digital sequence **4906**, the interrupts may be used for starting and/or stopping a timer. For example, a low state values (bit **0**) and a high state values (bit **1**) may be characterized as a short period and a long period, respectively.

Referring to FIG. **43**A, the implant may acknowledge the reception of a command by responding with an ACK message if the command does not contain any parameter. Referring to the FIG. **44**A, the control device may send a command with parameters. In one embodiment, the parameters and the Cyclic Redundant Check (CRC) code may be sent at about 2 ms intervals. If the CRC code verification is successful, the implant may then respond with an ACK message, which may confirm that the command is properly received. Otherwise, the implant may send a NACK message to prompt the control device to resend the command. As shown in FIGS. **45**A and **45**B, the data structures of the ACK message and the NACK message may be similar except for the last four bits.

Referring to FIG. **46**A, several commands may request information from the implant. In response, the implant may embed the requested information in a response message. Upon receiving the response message and the embedded information, the control device may respond with an ACK message.

In FIG. **46**B, a data structure of a response message is shown according to an embodiment of the present invention. Generally, the response message may include a start bit, two synchronization bits, eight "length" bits, several response message bits the size of which is defined by the value contains in the "length" bits, and eight CRC bits.

Referring to FIGS. **47**A and **47**B, several timeout conditions may be met when the implant takes more than 200 ms to send back either an ACK message or a response message. Generally, timeout conditions and/or a NACK message from the implant may trigger the resending of commands from the control device. According to an embodiment of the present invention, this resending mechanism may repeat up to about five times.

FIG. **50** shows a screen shot of the timing diagrams of the control device's command and the implant's response. The response time t_{resp} may be measured from the sending of the command **5010** (from the control device **110**) to the sending of the response **5020** (from the implant). The start pulse duration t_{sd} may be the duration for transmitting the first response pulse, and the data bit duration t_{db} may be the duration for transmitting one message data bit. In one embodiment, the start pulse duration t_{sd} may be set at 400 μs and the data bit duration t_{db} may be set at 200 μs. In order to instruct the microcontroller to stop its current task and get ready to receive the message, the start bit duration may be set to low.

The discussion now turns to the gastric band adjustment history storage function of the implant electronic system. In FIG. **48**, a data structure of implant adjustment history record **4800** (hereafter "history data record") may be shown according to an embodiment of the present invention. Generally, the history data record **4800** may reserve four bytes for storing gastric band position information, three bytes for storing date information, and one byte for storing CRC code.

Particularly, the gastric band position may be represented by about 71,000 motor steps, which may be stored in the four-byte data field. Because the EEPROM in the CAD has a size of about 512 bytes, information may normally be stored in duplicates of 256-byte size in a first record location and a second record location. Advantageously, the implant electronic device may be able to use the second set of records for data if the first set of records is corrupted.

The motor used in the implant may be a step motor. One step of the motor may correspond to one binary value stored in the counter. The stored value of "0" may represent a substantially (or fully) open band, while a stored value of "71,000" may represent a substantially (or fully) closed band. Moreover, more than one control devices may access and retrieve information from the implant, such that multiple care-takers and/or physicians may monitor and adjust the gastric band for the patient.

The discussion now turns to the operation of the motor. Referring to FIGS. **55**A-**55**B a perspective top view and a perspective bottom view of a motor **5500** according to an embodiment of the present invention. Generally, the motor **5500** may be used for implementing the functional features of the motor assembly **3718** as shown in FIG. **37**B. The motor **5500** may include the upper bearings **5504**, lower bearings **5508**, a set of motor gears **5505**, a first motor coil **5506**, a second motor coil **5507**, a maneuver channel **5510**, and a motor switch PCB **5530**.

The motor switch PCB **5530** may have a layer of gold plate over the copper layer and large pads for cleaner thermo soldering, and the set of motor gears **5505** may be covered by dry lubrication with a diamond like coating (DLC) to achieve better surface tension for avoiding water drop formation.

The maneuver channel **5510** may be used for receiving the threaded section of the flexible screw. When the set of gears **5505** are turned, the flexible screw may be maneuvered along the maneuver channel **5510**. In a band widening step, for example, the flexible screw may be maneuvered from the upper bearing **5504** side of the maneuver channel **5510** to the lower bearing **5508** side of the maneuver channel **5510**. In a band tightening step, for example, the flexible screw may be maneuvered from the lower bearing **5508** side of the maneuver channel **5510** to the upper bearing **5504** side of the maneuver channel **5510**.

The motor **5500**, the motor wires **5522**, and the flexible screw may be protected by several devices. Before entering the motor **5500**, for example, the motor wires **5522** may be protected by the motor cable **5524**. At or near the lower bearings **5508**, for example, the motor wires **5522** may be protected by a cable cone **5542** of a motor traveling PCB protection cap **5540**.

Referring to FIGS. **55**E-**55**F, a perspective bottom view and a perspective top view of a motor traveling PCB protection cap **5540** are shown according to an embodiment of the present invention. The motor traveling PCB protection cap **5540** may include the cable cone and a PCB brace **5544**. The cable cone **5542** may be used for protecting the motor wires **5522**. The PCB brace **5544** may be used for protecting the lower bearings **5508** and holding the motor switch PCB **5530**. The motor traveling PCB protection cap **5540** may be made of a PEEK material, and it may be mounted to the lower bearing **5508** of the motor **5500**.

FIGS. **55**C-**55**D show a perspective bottom view and a perspective top view of motor cap **5520** according to an embodiment of the present invention. The motor cap **5520** may cover the motor traveling PCB protection cap **5540** and thereby providing further protection for the lower bearing **5508** of the motor **5500**. The motor cap **5520** may define a maneuver aperture **5526**, which may help guide the longitudinal movement of the flexible screw **5560**. The motor cap **5520** may include a set of flanges **5527**, which may be used for anchoring to the skeleton **5800**. The motor **5500** may be partially secured by the motor cap **5520** and the motor traveling PCB protection cap **5540**. After receiving and securing the motor **5500**, the motor cap **5520** may anchor the motor **5500** to the skeleton **5800**. The motor cap **5520** may have several rails to allow silicone to form overmolding thereon.

The motor cable **5524** and part of the flexible screw may be further protected by an overmold motor sleeve. Referring to FIGS. **55**G-**55**H, a perspective side view and a perspective front view of a motor sleeve **5550** are shown according to an embodiment of the present invention. The motor sleeve **5550** may be made of an LSR silicon material overmolded on a PEEK material. The LSR silicon overmolded PEEK may provide a sealing surface to protect fluid from entering the motor **5500**. Moreover, the motor sleeve **5550** a plurality of internal bumps **5552** to facilitate even gluing between the interior of the motor sleeve **5550** and the motor cable **5524**.

FIG. **55**I shows an exploded view of a motor coil **5560** according to an embodiment of the present invention. Generally, the motor coil **5560** may be used for implementing the first and/or second motor coils **5506** and **5507**. Particularly, the motor coil **5560** may include a first connection board **5564**, a second connection board **5566**, a core **5562**, an inner shield **5570**, a coil body **5568**, and an outer shield **5572**.

The first and second connection boards **5564** and **5566** may provide a connection interface between the motor wires and the coil body **5568**. Moreover, the first and second connection boards **5564** and **5568** may help secure the coil body **5568** around the center of the core **5562**. The first and second connection boards **5564** and **5568** may engage the core **5562** and sandwich the coil body **5568** between both ends of the core **5562**. The coil body **5568** may have several coils that are made of silver wire. When current passes through the coils, the coil body **5568** may induce a magnetic flux along the core **5562**. The inner and outer shield **5570** and **5572** may shield the coil body **5568** from electromagnetic interference, such that the magnetic flux generated by one motor coil (e.g., the motor coil **5506** or **5507**) will not interfere with the magnetic flux generated by another motor coil (e.g., the motor coil **5507** or **5506**).

FIGS. **55**J-**55**K show various views of the motor cable **5524** according to an embodiment of the present invention. Generally, the motor cable **5524** may include a central conductor **5521**, nine twisted wires **5522**, and a PTFE tape **5525**. The central conductor **5521** may be crimped and attached to the motor **5500** on one end, and it may be crimped and soldered to the implant electronic system PCB **3722** on the other end. The central conductor **5521** may be a ground wire or a skeleton wire depending on the particular circuit configuration being used.

Specifically, the central conductor **5521** may include ninety-one MP35NLT alloy wires each with diameter of 0.04 mm. The nine twisted wires **5522** may be connected to the first and second motor coils or the end of a travel switch. Each of the nine twisted wires **5522** may include seven AISI316L silver plated stainless steel wires **5523**, each of which may have a diameter of 0.12 mm.

FIG. **56** shows a side view of a flexible screw assembly **5600** according to an embodiment of the present invention. Generally, the flexible screw assembly **5600** may be used for implementing the functional features of the flexible screw assembly **3720**. The flexible screw assembly **5600** may have a hook end **5602**, a central wire **5604**, an intercalary wire (threaded section) **5605**, and a crimped end **5608**. The central wire **5604** may be surrounded by the stabilizing tube as discussed in FIG. **37**B, and it may be attached to the end of the intercalary wire **5605** opposite to a crimped end **5608**. Moreover, the central wire **5604** may be used for controlling the size of the gastric band when the intercalary wire **5605** is being moved back and forth the maneuver channel **5510** of the motor **5500** (see FIGS. **55**A and **55**B).

The flexible screw assembly **5600** may have an overall length **5612** of about 136.20 mm and with a tolerant range of about 0.1 mm. The intercalary wire **5605** may have an overall length **5614** of about 52 mm and with a tolerant range of about 0.1 mm. The hook member **5602** may have a width **5601** and a length **5618**. The width **5601** may be about 2.5 mm and with a tolerant range of about 0.1 mm, whereas the length **5618** may be about 8 mm and with a tolerant range of about 0.1 mm.

FIGS. **57**A-**57**H provide various views of the motor **5500** engaging the flexible screw **5600** to illustrate the structural and functional relationships between the motor **5500** and the flexible screw assembly **5600**. Initially, each of the first and second motor coils **5506** and **5507** may receive a motor current from the implant electronic device PCB **3722** and via the motor wires **5522**. The first and second motor coils **5506** may each generate a magnetic flux in response to the received motor current. The generated magnetic flux may be collected by the stator **5547**, which may convert the magnetic flux to mechanical force for driving a set of rotors **5541**.

The set of rotors **5541** may be engaged to and for driving the set of gears **5505**. The set of gears **5505** may include a set of auxiliary gears **5543** and a primary gear **5545**. The set of auxiliary gears **5543** may be engaged between the rotor **5541** and the primary gear **5545**, such that the set of auxiliary gears **5543** may redirect the mechanical force from the rotor **5543** to the primary gear **5545**.

The primary gear **5545** may be positioned within the maneuver channel **5510**. The upper bearings **5504** and the lower bearings **5508** may help position, stabilize, and secure the primary gear **5545** within the maneuver channel **5510**. The primary gear **5545** may have an internal threaded section for engaging the external thread of the intercalary wire **5606** of the flexible screw **5600**. When the primary gear **5545** is set to rotate, it may move the intercalary wire **5606** along the maneuver channel **5510**. As such, upon receiving the mechanical force, the primary gear **5545** may actual a relative longitudinal movement between the motor **5500** and the flexible screw **5600**.

Because of the relative longitudinal movement actuated by the primary gear **5545**, the motor **5500** may slide along the intercalary wire **5606**. When the gastric band is formed, the hook end **5602** of the flexible screw **5600** may be positioned in the proximity of the motor **5500**. As such, the size of the gastric band, which can be defined in diameter and/or circumference, may be adjusted by varying a relative distance between the hook end **5602** and an engagement position on the intercalary wire **5606**. More specifically, the engagement position is a position at which the motor **5500** may engage the intercalary wire **5606**. The size of the gastric band may be increased by sliding the motor **5500** toward the crimped end **5608** of the flexible screw **5600**. Similarly, the size of the gastric band may be reduced by sliding the motor **5500** toward the hook end **5602** of the flexible screw **5600**.

The discussion now turns to the motor and the motor blockage detection mechanism. Referring to FIG. **51**, a schematic view of a motor coil current measurement system **5100** is shown according to an embodiment of the present invention. The connection between the motor and the implant electronic device may be established via ten conductor cable wires. The cable wires **5122** and **5124** may be connected to the screw end of a travel switch. In one embodiment, the cable wire **5122** may be one of the motor wires **5522**, and the cable wire **5124** may be the center conductor **5521** as shown in FIG. **55**K.

Generally, the eight cable wires connecting to the motor coils may be duplicated and connected in parallel. In one embodiment, for example, the cable wire **5102** may duplicate the cable wire **5104**, the cable wire **5106** may duplicate the cable wire **5108**, the cable wire **5112** may duplicate the cable wire **5114**, and the cable wire **5116** may duplicate the cable wire **5118**. Each of the cable wires **5102**, **5104**, **5106**, **5108**, **5112**, **5114**, **5116**, and **5118** may be implemented by one of the nine motor wires **5522** as shown in FIG. **55**K.

The cable wires **5102** and **5104** may be connected to a first end of the motor coil **2**, while the cable wires **5106** and **5108** may be connected to a second end of the motor coil **2**. Similarly, the cable wires **5112** and **5114** may be connected to a first end of the motor coil **1**, while the cable wires **5116** and **5118** may be connected to a second end of the motor coil **1**.

As previously discussed, the control device may request the patient's identification number and history data from the implant electronic system before the gastric band adjustment process. In response, the implant electronic system may retrieve and send back the requested information. After receiving the requested information, the control device may be ready for adjustment. At this point, the user may elect to tighten or loosen the gastric band.

When the electronic device receives band adjustment commands from the control device, it may initiate a motor-on sequence which may include a motor positioning phase, a motor startup phase, and a motor drive phase. During the motor position phase, the motor is moved to a known position prior to the actual rotation start. Table 3 may illustrate the motor positioning phase:

TABLE 3

Sequences during motor positioning.

Direction	Duration [ms]	Coil 1	Coil 2
Band Closing	5	NEG	POS
	60	NEG	NEG
Band Opening	5	POS	POS
	60	POS	NEG

A positive pulse POS and a negative pulse NEG may be used for driving the motor coils. During a band closing sequence, for example, the first motor coil may receive a negative pulse for 5 ms and then another negative pulse for 60 ms, whereas the second motor coil may receive a positive pulse for 5 ms and a negative pulse for 60 ms. Table 4 may provide four pulse pair steps for rotating the motor:

TABLE 4

Sequences for motor rotation.

Pulse Pair	Band Closing		Band Opening	
Label	Coil 1	Coil 2	Coil 1	Coil 2
PPL0	POS	NEG	NEG	NEG
PPL1	POS	POS	NEG	POS
PPL2	NEG	POS	POS	POS
PPL3	NEG	NEG	POS	NEG

The pulse pair (PP) combination parameters may be stored in the implant electronic device's EEPROM. Generally, two pairs of pulses may drive a full turn of the motor, thereby completing a single motor step. Accordingly, two motor steps may be completed after executing pulse pairs PPL0 to PPL3. The completion of each motor step may be reported back to the control device for monitoring purposes. During the motor startup phase, the duration of the pulses may be gradually decreased from about 5.12 ms down to about 2.6 ms with a delta of about 0.15 ms after each pulse.

During the motor drive phase, a motor blockage may be detected. The motor drive phase may be used for refining a minimal pulse duration, which may range from about 2.6 ms to about 1.2 ms. The minimal pulse duration may allow the motor coils to turn smoothly without any motor blockage.

Referring again to FIG. **51**, the minimal pulse duration may be refined by detecting the motor coil currents across the resistors **5132** and/or **5134**. The motor coil currents may be amplified by an analog amplifier and then digitized by an analog-to-digital converter (ADC). In one embodiment, the analog amplifier may be configured to have an amplifying power of 32, and the ADC may be configured to generate a 10-bit digital number for representing the value of the motor coil current.

Generally, the resistance of the resistors **5132** and **5134** may be much smaller than the resistance of the motor coils **5142** and **5144**. In one embodiment, for example, the resistance of the motor coil **5142** or **5144** may be 167 times of the resistance of the resistor **5132** or **5134**. In another embodiment, for example, the resistance of the resistors **5132** and **5134** may each be about 3.6Ω, whereas the resistance of the motor coils **5142** and **5144** may each be about 600Ω. As such, the voltage drop across the resistors **5132** and **5134** may be minimal when compared to the voltage drop across the motor coil resistors **5142** and **5144**. Therefore, the resistance of the resistors **5132** and **5134** may have little effect on the overall current flowing of the first and second motor coils.

Sources of motor blockage may include increased force required to close the band as its materials get more compressed. As the radius of the band reduces, it would also become more difficult to pull on the flexible screw **5600** regardless of the presence of other materials. Biological tissue also gets more compressed as radius decreases, leading to more required force from the motor. The motor may be rated at a pulling force of 20 N but with typical pulling force of 27 N, such that it would get stalled as the required force would be higher than the typical pulling force.

The trend of motor coil current may indicate motor blockage or the lack thereof. As shown in FIG. **52**, for example, a first current profile **5206** may represent a motor coil current of an unblocked motor, and a second current profile **5208** may represent a motor coil current of a blocked motor. In general, the resistance of a blocked motor may be higher than an unblocked motor. To maintain a relatively constant voltage across the motor, the motor coil current of a blocked motor (e.g., the second current profile **5208**) may increase rapidly during an initial period **5201** of a motor step but slowly during a middle period **5202** of the motor step.

On the other hand, the resistance of an unblocked motor is typically lower than that of a blocked motor. As such, the motor coil current of an unblocked motor (e.g., the first current profile **5206**) may increase slowly during the initial period **5201** but rapidly during the middle period **5202**. Both motor coil currents (e.g., the first and second current profiles **5206** and **5208**) may reach a maximum motor coil current **5209** at an ending period **5204** of the motor step. However, during the middle period **5202**, the integral sum of the blocked motor coil current (e.g., the second current profile **5208**) may be much greater than the integral sum of the unblocked motor coil current (e.g., the first current profile **5206**). This phenomenon may be attributed by the early ramping of the blocked motor coil current and the late ramping of the unblocked motor coiled current.

Based on several measurements, the integral sum of the blocked motor current during the middle period **5202** is typically greater than the maximum motor coil current **5209**. To the contrary, the integral sum of the unblocked motor current during the middle period **5202** is typically less than the maximum motor coil current **5209**. As such, the integral sum of a particular motor coil current during the middle period **5202** may be compared to the maximum motor coil current **5209** in determining whether the motor is blocked.

According to an embodiment of the present invention and as shown in FIG. **54**, the implant electronic device (e.g., a processing device) may execute a software algorithm for detecting motor blockage. The software algorithm may take advantage of the aforementioned principle, and it may be stored in a tangible computer readable medium. In one embodiment, for example, the tangible computer readable medium may include a flash memory in the implant electronic device. In another embodiment, for example, the tangible computer readable medium may include, but not limited to, random access memory (RAM), flash memory, read-only memory (ROM), EPROM, EEPROM, registers, hard disk, removable disk, CD-ROM, DVD, Blu-ray disk, wireless channels, and various other media capable of storing, containing or carrying instruction(s) and/or data. In yet another embodiment, the motor coil current may be measured by the implant electronic device, while the motor blockage detection software algorithm may be stored in and executed by the control unit.

In step **5302**, an integral sum value (idt) may be calculated by measuring the integral sum of motor coil current (Integral_idt) and normalizing the measurement. In one embodiment, the measurement may be performed during the PPL2 pulse pair, and the normalization may be performed by multiplying the measured integral sum of motor coil current (Integral_idt) by a predetermined parameter (constant idt).

In step **5304**, the maximum current (crt) may be calculated by measuring the maximum motor coil current (Current_Max) and normalizing the measurement. In one embodiment, the measurement may be performed during the PPL3 pulse pair, and the normalization may be performed by multiplying the measured maximum motor coil current (Current_Max) by a predetermined parameter (constant_Max).

In step **5308**, a determination can be made regarding whether the integral sum value (idt) is greater than the maximum current (crt). If a positive determination is made, the algorithm may proceed to step **5308**, in which the value of a block register (iBlock) may be augmented. The block register value augmentation may be representative of the possibility that the motor is blocked. Hence, the higher the value of block register is, the more likely that the motor blockage has occurred.

On the other hand, if a negative determination is made in step **5308**, the algorithm may proceed to step **5312**, in which the value of the block register (iBlock) may be compared with a predefined value. If the value of the block register is less than the predefined value, a reduction step **5316** may be executed for reducing the value of the block register. In one embodiment, the value of the block register may be a negative number. If the value of the block register is greater than the predefined value, an increment step **5314** may be executed for augmenting the value of the block register.

In step **5320**, a determination is made regarding whether a motor blockage has occurred. The value of the block register may be compared with a predefined threshold. The predefined threshold may represent a threshold probability that a motor blockage has occurred. If the value of the block register does not reach the predefined threshold, the algorithm may assume no motor blockage has happened yet, and it may return to step **5302** for the next motor sequence. However, if the value of the block register exceeds the predefined threshold, the algorithm may determine that the motor is blocked, and it may enter a different sequence.

Once a motor blockage is detected, the implant electronic device may direct the motor to decrease its speed and to enhance the motor torque. In one embodiment, for example, the implant electronic device may decrease the pulse duration to about 1.2 ms to produce more motor torque. If the motor load decreases, thereby requiring less motor torque, the implant electronic device may direct the motor to increase its speed again.

The discussion now turns to several gastric band components. Referring to FIGS. **58**A-**58**C, various views of a bendable skeleton **5800** may be shown according to an embodiment of the present invention. Generally, the bendable skeleton **5800** may be used for implementing the functional features of the skeleton **3814**. The bendable skeleton may be made of a PEEK material, which may be corrosion resistive and durable against stress.

The bendable skeleton **5800** may have an open compartment **5802** for receiving and securing the motor, a ladder body **5804** for supporting the dorsal ring surface of the gastric band, and a distal end member **5806** for providing an anchor point for the hook end (element) **5602** of the flexible screw **5600** to the first end of the dorsal element. The ladder body **5804** may also embrace the stabilizing tube **5820**. In return, the stabilizing tube **5802** may guide the center wire of the flexible screw assembly to travel from the open compartment **5802** to the distal end member **5806** of the bendable skeleton **5800**.

The open compartment **5802** may have a diameter **5808**, a vertical distance **5810** separating the open compartment **5802** and the distal end member **5806**, and an overall length **5812**. In one embodiment, the diameter **5805** may be about 13.6 mm, the vertical distance **5810** may be about 67.6 mm, and the overall length **5812** may be about 111.23 mm.

FIGS. **59**A-**59**B show a perspective view and a cross-sectional view of the stabilizing tube **5820** according to an embodiment of the present invention. Generally, the stabilizing tube **5820** may be made of an ePTFE material. The stabilizing tube **5820** may have an overall length **5912**, a first height **5914**, a second height **5916**, a radius **5922**, a thickness **5920**, and a channel radius **5918**. In one embodiment, the overall length **5912** may be about 130 mm, the first height **5914** may be about 2.55 mm, the second height **5916** may be about 4.4 mm, the radius **5922** may be about 5 mm, the thickness **5920** may be about 3.5 mm, and the channel diameter **5918** may be about 3 mm.

FIGS. **60**A-**60**D show various views of a dorsal element **6000** according to an embodiment of the present invention. Generally, the dorsal element **6000** may be used for implementing the functional features of the dorsal element **3704** as shown in FIG. **37**B. The dorsal element **6000** may include an open compartment **6001**, an opening **6002**, and a semi-tubular ring (body) **6022** connecting the open compartment **6001** and the opening **6002**. The side wall of the open compartment **6001** may have a locking protrusion and a ring-locked indicator **6030** formed on the locking protrusion. During the band formation, the open compartment **6001** may be inserted into the opening **6002**, which may have a clip ring with a locking flange **6006**. The locking flange may have a port for securing the locking protrusion. Once the locking protrusion is secured by the flange port, the ring-lock indicator **6030** may become visible.

FIGS. **61**A-**61**C show various views of an anti-slip cushion **6100** according to an embodiment of the present invention. The cushion **6100** may have a width **6102**, a thickness **6104**, a first length **6106**, and a second length **6110**. In one embodiment, the width **6102** may be about 17.92 mm, the thickness **6104** may be about 4.42 mm, the first length **6106** may be about 17.3 mm, and the second length **6110** may be slightly shorter than the first length **6106**.

The front surface of the cushion **6100** may be symmetrical along a vertical axis, and it may have a convex shield-like surface with an array of curvy groove lines **6108** to provide more friction. Advantageously, the curvy groove lines **6108** may help the gastric band to remain in contact with the patient stomach and reduce the likelihood of band slippage. Moreover, the shield-like convex surface of the cushion **6100** may efficiently stimulate the vagus nerve of the patient.

FIGS. **62**A-**62**C show various views of a membrane shell **6200** according to an embodiment of the present invention. In general, the membrane shell **6200** may include a tubular structure made of several segments **6208**. The tubular structure **6202** may have a circular contour, and it may be used for encapsulating the dorsal element **6000**, the skeleton **5800**, and part of the flexible screw **5600**. The segments **6208** may be used for receiving the cushions **6100**. The membrane shell **6200** may be made of several NuSil LSR silicones, depending on the level of hardness it is designed to achieve. In one embodiment, for example, the membrane shell **6200** may be made of MED-4870, which is a silicone with a hardness of about 70 Shore A.

FIGS. **63**A-**63**C show various views of a cushioned membrane shell **6300** according to an embodiment of the present invention. The cushioned membrane shell **6300** may include several cushions **6308**, which may be made of MED-4801. When compared to MED-4870, MED-4801 may have a hardness of about 1 Shore A. Accordingly, the cushioned membrane shell **6300** may have a soft inner circumferential surface and a hard outer circumferential surface.

In an alternative embodiment, the cushions **6308** may be made of a silicone elastomer external shell filled with saline solution or made of a silicone elastomer external shell filled with silicone gel. Specifically, the silicone elastomer for the cushions may have a hardness ranges from about 1 Shore A to about 10 Shore A, whereas the silicone elastomer for the membrane shell may have a hardness ranges from about 20 Shore A to about 45 Shore A.

Unless otherwise indicated, all numerical parameters used in the specification and claims are to be understood as being modified in all instances by the term "about." Accordingly, unless indicated to the contrary, the numerical parameters set forth in the specification and attached claims are approximations that may vary depending upon the desired properties sought to be obtained by the present invention. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques. Notwithstanding that the numerical ranges and parameters setting forth the broad scope of the present invention are approximations, the numerical values set forth in the specific examples are reported as precisely as possible. Any numerical value, however, inherently contains certain errors necessarily resulting from the standard deviation found in their respective testing measurements.

The terms "a," "an," "the," and similar referents used in the context of describing the present invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. Recitation of ranges of values herein is merely intended to serve as a shorthand method of referring individually to each separate value falling within the range. Unless otherwise indicated herein, each individual value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein is intended merely to better illuminate the present invention and does not pose a limitation on the scope of the present invention otherwise claimed. No language in the specification should be construed as indicating any non-claimed element essential to the practice of the present invention.

Groupings of alternative elements or embodiments of the invention disclosed herein are not to be construed as limitations. Each group member may be referred to and claimed individually or in any combination with other members of the group or other elements found herein. It is anticipated that one or more members of a group may be included in, or deleted from, a group for reasons of convenience and/or patentability. When any such inclusion or deletion occurs, the specification is deemed to contain the group as modified thus fulfilling the written description of all Markush groups used in the appended claims.

Certain embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. Of course, variations on these described embodiments will become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventor expects skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than specifically described herein. Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

Furthermore, certain references have been made to patents and printed publications throughout this specification. Each of the above-cited references and printed publications are individually incorporated herein by reference in their entirety.

Specific embodiments disclosed herein may be further limited in the claims using consisting of or consisting essentially of language. When used in the claims, whether as filed or added per amendment, the transition term "consisting of" excludes any element, step, or ingredient not specified in the claims. The transition term "consisting essentially of" limits the scope of a claim to the specified materials or steps and those that do not materially affect the basic and novel characteristic(s). Embodiments of the invention so claimed are inherently or expressly described and enabled herein.

In closing, it is to be understood that the embodiments of the present invention disclosed herein are illustrative of the principles of the present invention. Other modifications that may be employed are within the scope of the present invention. Thus, by way of example, but not of limitation, alternative configurations of the present invention may be utilized in accordance with the teachings herein. Accordingly, the present invention is not limited to that precisely as shown and described.

What is claimed is:

1. A remotely powered and remotely adjustable gastric band system, comprising:

a remote control device configured to transmit a telemetric signal having an amplitude and a carrier frequency, wherein a magnitude of the amplitude of the telemetric signal varies to adjust a transmitted power of the telemetric signal in response to a telemetric feedback signal received by the remote control device;

an implantable power device telemetrically coupled to the remote control device, and configured to convert the transmitted power of the telemetric signal and to generate the telemetric feedback signal in response to the implantable power device sensing that the converted power exceeds a predetermined threshold, the telemetric feedback signal having a message frequency based on a difference between the converted power and the threshold; and

a gastric band for forming a ventral ring surface around a stomach of a patient, the gastric band coupled to the implantable power device, and configured to receive at least a portion of the converted power from the implantable power device and adjust the ventral ring surface in response to the telemetric signal transmitted from the remote control device.

2. The gastric band system of claim **1**, wherein the implantable power device includes:

an implantable antenna for receiving the telemetric signal from the remote control device,

a rectifying device coupled to the implantable antenna, and configured to rectify the received telemetric signal to form a DC input voltage at a DC input node,

a power sensing device configured to receive a DC input voltage and generate a regulation signal when the DC input voltage exceeds a predetermined threshold,

a regulation device coupled to the power sensing device, and configured to generate a regulation voltage in response to the regulation signal, and

a frequency modulation device coupled to the regulation device, and configured to generate a frequency modulation signal with a modulated frequency representing the regulation voltage,

wherein the message frequency of the feedback signal tracks the modulated frequency of the frequency modulation signal.

3. The gastric band system of claim **2**, wherein the implantable power device includes:

a switch coupled to the frequency modulation device, and configured to perform an amplitude modulation at the implantable antenna, the amplitude modulation adjusting the amplitude of the telemetric signal based on the frequency modulation signal.

4. The gastric band system of claim **1**, wherein the remote control device includes:

an external antenna configured to transmit the telemetric signal and receive the feedback signal,

a sensing device coupled to the external antenna, and configured to sense the feedback signal,

a demodulation device coupled to the sensing device, and configured to extract the message frequency from the sensed feedback signal and generate a voltage control signal based on the message frequency, and

a modulation device coupled to the demodulation device and the external antenna, and configured to adjust the amplitude of the telemetric signal based on the voltage control signal and transmit the adjusted telemetric signal to the external antenna.

5. The gastric band system of claim **4**, wherein the sensing device includes a directional coupler configured to separate the feedback signal from the telemetric signal.

6. The gastric band system of claim **1**, wherein the threshold power is associated with a physical condition of the implantable power device when the implantable device is subject to a power level at or above the threshold power.

7. The gastric band system of claim **1**, wherein the threshold power is associated with an overheating condition of the implantable power device when the implantable device is subject to a power level at above the threshold power.

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